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SILVER BOW CREEK

REMEDIAL INVESTIGATION FINAL REPORT
APPENDIX E, PART 3

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SILVER BOW CREEK REMEDIAL INVESTIGATION
REVISED DRAFT FINAL REPORT

FISH TISSUE INVESTIGATION

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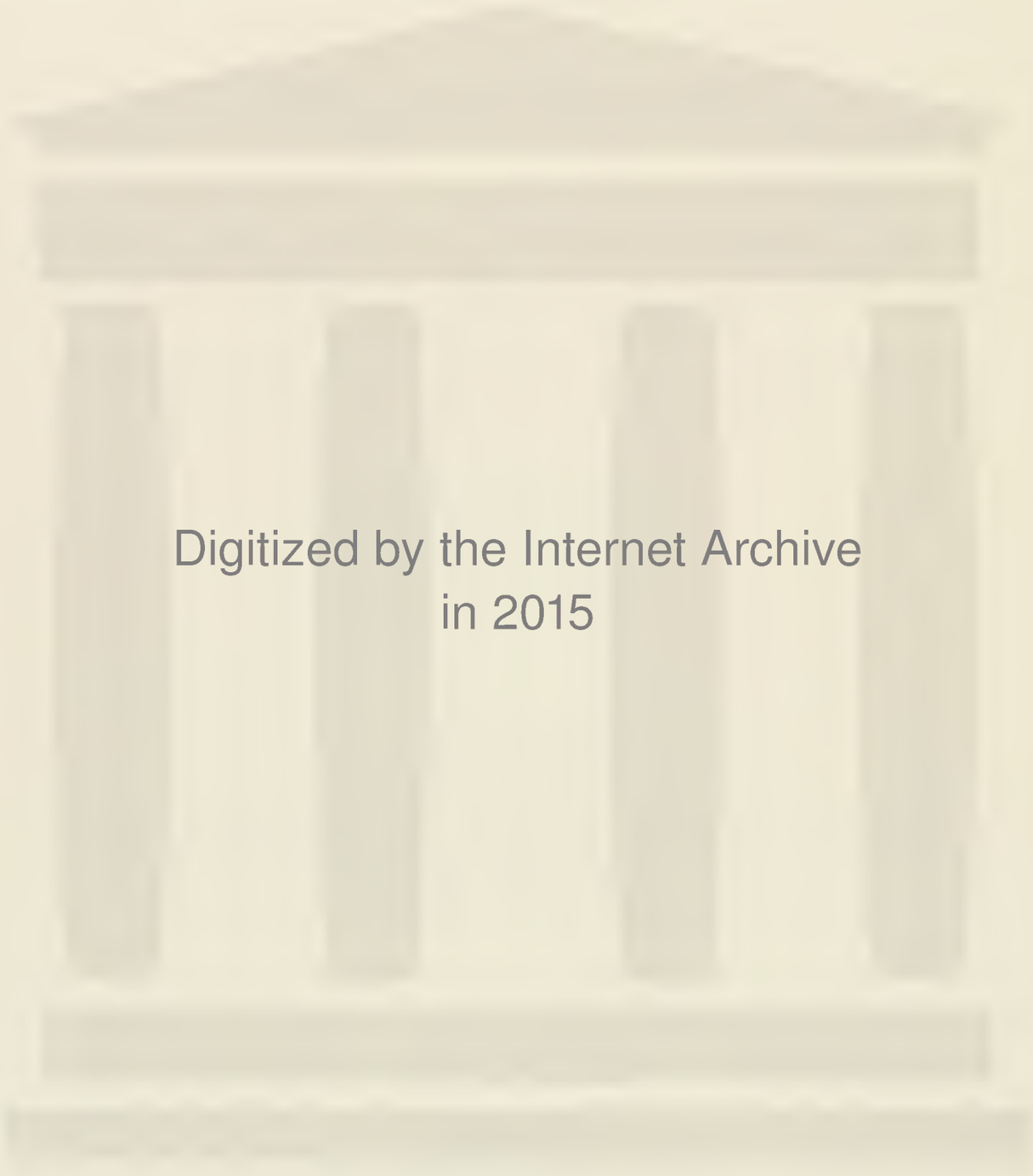
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PREFACE

Silver Bow Creek originates north of Butte, Montana and is a major tributary to the upper Clark Fork River. Mill tailings and other mining wastes in and near the creek contribute to substantial downstream contamination, particularly by potentially toxic elements: arsenic, cadmium, copper, lead, iron, and zinc. These elements and others were present in the mine ore and remain as by-products of the milling and smelting processes.

The history of mining in the Butte area began with the discovery of placer gold in Silver Bow Creek, in late summer of 1864. Several townsites and camps sprung up among the diggings. However, these operations were short-lived, and most of the miners left by 1869. Those who stayed began prospecting the quartz lode deposits of silver and the associated complex copper ores on the Butte Hill. Their efforts culminated in a silver rush, which began in the mid-1870's and revived the old camp. During that time world-class deposits of copper ore were identified. By 1881, Butte had become one of the nation's major mining centers; the district attained national dominance in copper mining by the mid-1890's and international prominence by the turn of the century. By 1915, Anaconda Copper Mining Company led the industry; but in 1980, in response to a depressed copper market, Anaconda closed all the underground mines and continued active mining only in the Berkeley Pit (established in 1955). In 1977, Anaconda became a subsidiary of Atlantic Richfield Company (ARCO). ARCO closed the Berkeley Pit in 1982 and the East Berkeley pit in 1983.

In addition to mining, various ore processing facilities also operated in the Butte area. The first two mills were erected in 1874 to smelt gold and silver. Ten years later, Marcus Daly, one of the founders of the Anaconda Company, built a copper smelter 27 miles west of Butte and planned the city of Anaconda. The Anaconda Smelter was moved to a new location in the city in 1900, and operated from 1903 to 1980.

The history of over 100 years of continuous mining and related activities changed the area's natural environment greatly. Early mining, milling, and smelting wastes were dumped directly into Silver Bow Creek and transported downstream to the Clark Fork River. In 1911, the first treatment pond was built by Anaconda Company near Warm Springs, Montana, to settle out wastes from Silver Bow Creek before the water was allowed to move on. In 1916 and 1959, two more treatment ponds began operation. Silver Bow Creek continued to receive raw mining and milling wastes until 1972, when a treatment plant was added to the Weed Concentrator in Butte. Creek contamination problems were compounded by urban and domestic sewage, wood products treatment plants, phosphate and manganese production facilities, and chemical factories.

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In 1983, the U.S. Environmental Protection Agency (USEPA) designated Silver Bow Creek, contiguous portions of the upper Clark Fork River, and their environs as a high priority Superfund clean-up site. The site extends from Butte to Deer Lodge, Montana, generally following the course of Silver Bow Creek and the upper Clark Fork River. Because the various mining activities interrupted the natural flow of Silver Bow Creek, the beginning of the creek for this investigation was established as the confluence of the Metro Storm Drain and Blacktail Creek, within the city limits of Butte. The site begins at the start of the Metro Storm Drain and ends at the Kohrs Bridge north of Deer Lodge.

The Silver Bow Creek Remedial Investigation (SBC RI) project consisted of coordinated individual studies to develop data on the extent and severity of contamination within the site. Results of the studies are reported in several volumes. A Summary Final Report discusses the entire project; final reports for each individual study have been issued as appendices to the Summary, as shown below:

- Surface Water and Point Source Investigation, Appendix A, Parts 1-3;
- Ground Water and Tailings Investigation, Appendix B, Parts 1-3;
- Warm Springs Ponds Investigation, Appendix C;
- Algae Investigation, Appendix D, Part 1;
- Vegetation Mapping, Appendix D, Part 2;
- Agriculture Investigation, Appendix D, Part 3;
- Macroinvertebrate Investigation, Appendix E, Part 1;
- Bioassay Investigation, Appendix E, Part 2;
- Fish Tissue Investigation, Appendix E, Part 3;
- Waterfowl Investigation, Appendix E, Part 4; and
- Laboratory Quality Assurance/Quality Control Program, Appendix F.

The Solid and Hazardous Waste Bureau (SHWB) of the Montana Department of Health and Environmental Sciences (MDHES) administered the USEPA appropriations to conduct this project. The Montana SHWB program manager was Mr. Michael Rubich. MDHES contracted with MultiTech in October 1984 to perform the SBC RI under contract No. 50341-1202503. The Project Manager at MultiTech was Mr. Gordon Huddleston.

MultiTech was assisted in the SBC RI work by Stiller and Associates of Helena and various other subcontractors. Several state and federal agencies also provided technical information and expertise, including the USEPA bioassay team, the Montana Department of Fish, Wildlife and Parks, the Montana Water Quality Bureau, and the USEPA Montana Field Office.

Information developed in the SBC RI will be used in the next phase of the project, the Feasibility Study, to evaluate options for site remediation.

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EXECUTIVE SUMMARY

The objective of the Fish Tissue Investigation for the Silver Bow Creek Remedial Investigation was to evaluate arsenic, cadmium, copper, zinc, polychlorinated biphenyls (PCB) and pentachlorophenol (PCP) contamination in fish residing in the Warm Springs Ponds.

Arsenic concentrations in all tissues tested were below USDA food standards. Cadmium appears to be bioaccumulating in the livers of the Warm Springs Ponds fish, but nearly one-half pound per week of fish liver would have to be consumed by an individual before the existing human health standard for cadmium intake would be exceeded. Copper appears to be bioaccumulating in both liver and muscle tissue, but concentrations exceed food standards only in the liver. Although zinc also appears to be bioaccumulating, it was not found at concentrations exceeding food standards in any tissues tested.

Measurable concentrations of PCP and PCB were found in the tissues tested. To exceed the USEPA One-Day Health Advisory--No Observed Adverse Affect levels, a 22-lb child would have to consume 91 lbs of worst-case PCP concentration fillet. To exceed the Ten-Day and Lifetime Health Advisory, the same child would have to consume 27 lbs per day of the worst-case PCP concentration fillet. None of the ten tissues tested exceeded the FDA tolerance level for PCB in Fish.

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1.0 INTRODUCTION

The objective of the Silver Bow Creek Remedial Investigation (SBC RI) is to determine the extent and severity of contamination in Silver Bow Creek and the upper Clark Fork River (Map 1-1). A description of the major events that led to the contamination of this system is found in Figure 1-1. The major sources of contaminants in this area are tailings deposits and contaminated ground water (see SBC RI Surface Water and Ground Water Reports, Appendices A and B). The contaminants being investigated by the SBC RI are arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), and zinc (Zn).

Data developed by the SBC RI will be used to evaluate environmental and human risk from the contaminants and to identify potential remedial actions. These activities will occur as part of the Feasibility Study, the next phase of action for the Silver Bow Creek site.

To evaluate risk, the migration of site contaminants into crops and animals consumed by humans needed to be determined during the RI phase. For the Silver Bow Creek Site, three investigations were performed to allow this evaluation:

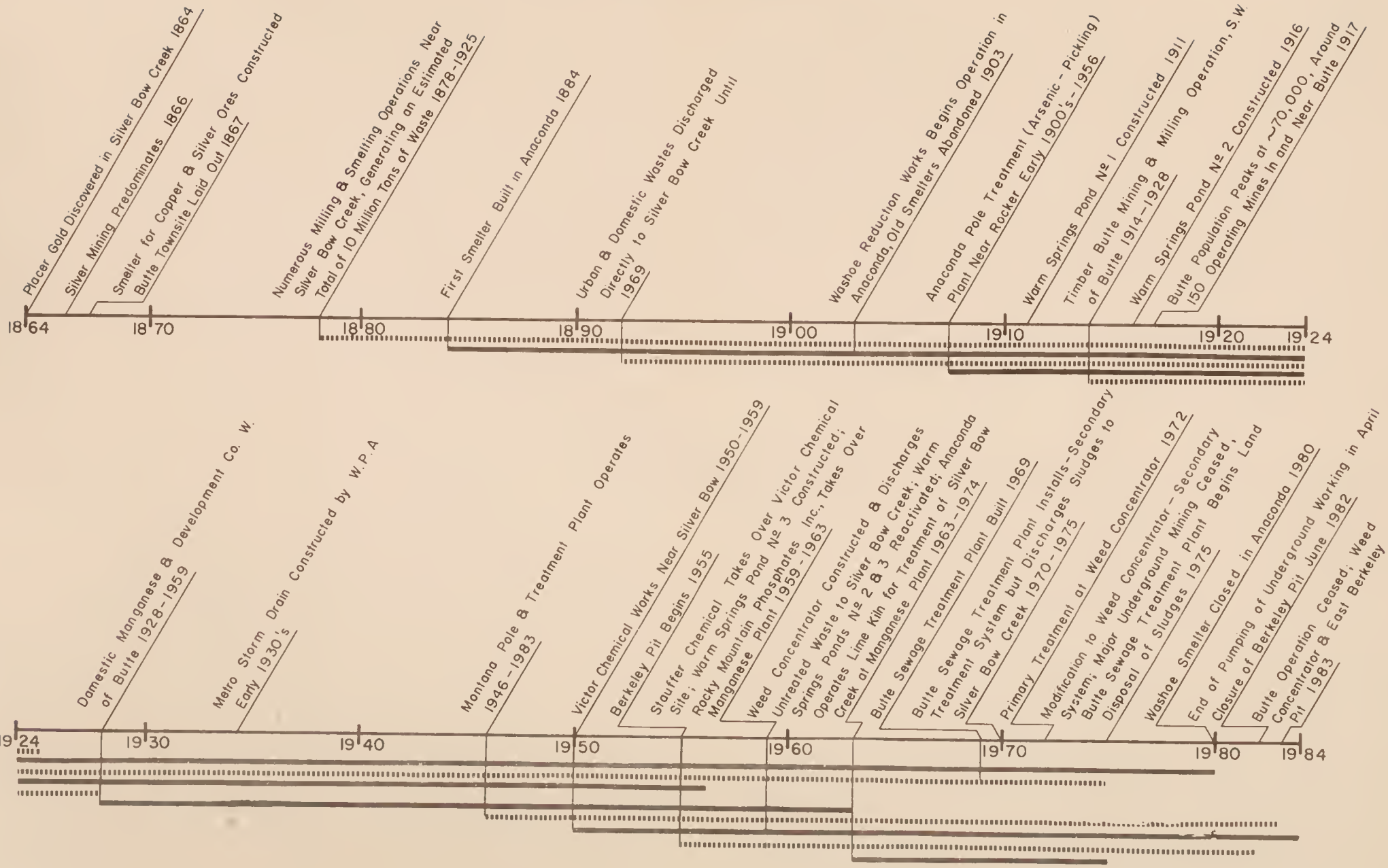
- SBC RI Agricultural Investigation.
- SBC RI Waterfowl Investigation.
- SBC RI Fish Tissue Investigation.

This report documents the findings of the Fish Tissue Investigation.

CONTINENTAL DIVIDE
YANKEE DOODLE POND
BERKELEY PIT
BUTTE
BLACKTAIL CR.
BASIN CR
LITTLE BASIN CR
CLARK TAILINGS
COLORADO TAILINGS
ROCKER
BROWNS GULCH
SILVER BOW
RAMSAY
DAWSON
MILES CROSSING
FLINT CR.
SCALE 1" = 2.27 MILES
COTTONWOOD CR.
PETERSEN CR.
CARIBOU CR.
CLARK FORK
DRY COTTONWOOD CR
OEER LODGE
DEMPSEY
GALEN
WARM SPRINGS PONDS
WARM SPRINGS
SILVER BOW CREEK
FAIRMONT HOT SPRINGS
GERMAN GULCH
TAYLOR CR.
POWELL CR.
DEMPSEY CR
RACETRACK CR
MODESTY CR
LOST CR.
WARM SPRINGS CR
MILL CR
WILLOW CR
SILVER BOW CREEK
MAP 1-1
SILVER BOW CREEK
and UPPER
CLARK FORK RIVER

FIGURE 1-1

HISTORIC CONTAMINATION OF SILVER BOW CREEK


Placer Gold Discovered in Silver Bow Creek 1864
Silver Mining Predominates 1866
Smelter for Copper & Silver Ores Constructed
Butte Townsite Laid Out 1867
Numerous Milling & Smelting Operations Near Silver Bow Creek, Generating an Estimated Total of 10 Million Tons of Waste 1878-1925
First Smelter Built in Anaconda 1884
Urban & Domestic Wastes Discharged Directly to Silver Bow Creek Until 1969
Washoe Reduction Works Begins Operation in Anaconda, Old Smelters Abandoned 1903
Anaconda Pole Treatment (Arsenic - Pickling) Plant Near Rocker Early 1900's-1956
Warm Springs Pond Nº 1 Constructed 1911
Timber Butte Mining & Milling Operation, S.W. of Butte 1914-1928
Warm Springs Pond Nº 2 Constructed 1916
Butte Population Peaks at ~70,000, Around 150 Operating Mines in and Near Butte 1917
1864
1870
1880
1890
1900
1910
1920
1924
Domestic Manganese & Development Co. W. of Butte 1928-1959
Metro Storm Drain Constructed by W.P.A. Early 1930's
Montana Pole & Treatment Plant Operates 1946-1983
Victor Chemical Works Near Silver Bow 1950-1959
Berkeley Pit Begins 1955
Stauffer Chemical Takes Over Victor Chemical Site; Warm Springs Pond Nº 3 Constructed; Rocky Mountain Phosphates Inc., Takes Over Manganese Plant 1959-1963
Weed Concentrator Constructed & Discharges Untreated Waste to Silver Bow Creek; Warm Springs Ponds Nº 2 & 3 Reactivated; Anaconda Operates Lime Kiln for Treatment of Silver Bow Creek at Manganese Plant 1963-1974
Butte Sewage Treatment Plant Built 1969
Butte Sewage Treatment Plant Installs-Secondary Treatment System but Discharges Sludges to Silver Bow Creek 1970-1975
Primary Treatment at Weed Concentrator 1972
Modification to Weed Concentrator-Secondary System; Major Underground Mining Ceased, Butte Sewage Treatment Plant Begins Disposal of Sludges 1975
Washoe Smelter Closed in Anaconda 1980
End of Pumping of Underground Working in April Closure of Berkeley Pit June 1982
Butte Operation Ceased; Weed Concentrator & East Berkeley Pit 1983
1924
1930
1940
1950
1960
1970
1980
1984

1.1 STUDY PLAN DEVELOPMENT AND OBJECTIVES

The consumption of fish residing in the contaminated water of the Silver Bow Creek/Upper Clark Fork River System is a potential pathway of human exposure to toxic elements, but the concentrations of contaminants in the edible fish tissues must to be known for a complete Feasibility Study and Risk Assessment. Because no fish live in Silver Bow Creek, exposure was not a concern for this part of the site. However, the fish from the Warm Springs Ponds and the upper Clark Fork River may be eaten, and data on them was needed.

Phillips (1982), Van Meter (1974), and Dent (1975) studied metal concentrations in the fish of the Upper Clark Fork River. Their research met RI data requirements, so additional studies on this area were not recommended. Studies of fish in the Warm Springs Ponds were recommended, however, as no data existed on them. These fish are not legally consumed, as the Warm Springs Ponds are a catch-and-release area by order of the Montana Department of Fish, Wildlife and Parks (MDFWP); however, their easy accessibility and large size make them tempting to poachers. Table 1-1 lists some metals and their potential for bioaccumulation. This table was used in selecting metals of analysis.

The SBC RI Work Plan's design for the Fish Tissue Study (MultiTech and Stiller and Associates 1984a) recommended the sampling and analysis methodology presented in Table 1-2. However, after consulting with Wayne Hadley of the MDFWP in Deer Lodge, the MDHES,

TABLE 1-1
POTENTIAL FOR BIOACCUMULATION OF TOXIC
TRACE ELEMENTS IN MAMMALS, BIRDS, AND FISH

Element	Potential for Bioaccumulation[a]	Warm Springs Ponds Interest
Antimony	Low	
Arsenic	Moderate	High
Beryllium	Low	
Boron	Low	
Cadmium	High	High
Chromium	Moderate	Moderate
Cobalt	Low	
Copper	High	High
Lead	High	High
Mercury	High	Low
Nickel	Moderate	Moderate
Selenium	Moderate	Moderate
Tin	Moderate	
Vanadium	Low	
Zinc	NL[b]	High

(a) Source: EPA 1981.
(b) NL = Not Listed.

TABLE 1-2

WARM SPRINGS PONDS FISH TISSUES INVESTIGATION
AS FOUND IN THE WORK PLAN AND CONSENSUS PLAN

Collection and Analysis Specification	Work Plan	Consensus Plan
Dates of Sampling	Once as Convenient	Same
Location of Sampling	Pond 2	Wildlife Ponds
Species Sampled	Trout, Brown or Rainbow	Rainbow Trout
Number of Individuals of each Species at each Period at each Place	25(a)	10:5 for metals, 5 for Organics
Age of Individuals of each Species	Age Class III	Same
Collection Method	Shocking	Gill net
Tissues for Analysis	Edible portion: a fillet including skin	Edible portion: a fillet including skin, liver, reproductive tissue
Tissue Preparation Method	Dissect followed by hot acid digest	Dissect followed by hot acid digest
Laboratory Analysis Method	AAS, ICAPES	AAS, GC, ICAPES
Parameters to be Measured	As, Cd, Cu, Pb, Zn	As, Cd, Cu, Zn, PCP, PCB
Data Summary and Statistics	ANOVA and Means Tests	None.

(a) Determined by statistical analysis of available Clark Fork River data to calculate number of samples required to reach a pre-determined level of confidence in the means generated.

MultiTech, and Mr. Hadley came to a consensus on the plan of study to be implemented. This plan also is presented in Table 1-2.

The Work Plan design proposed a sample size large enough to have statistical confidence in the data generated. However, because of the small size of the population to be sampled, an unacceptably high proportion would be removed. Therefore, the concensus sampling plan was not designed to yield statistical significance, but only to assess the general population.

The original sampling plan also was designed to provide a statistical evaluation of metal concentrations in the edible portion of the fish residing in the Warm Springs Ponds. Edible tissue was selected for analysis as providing data for human risk assessment, which was MDHES' highest priority. The consensus plan reduced the statistical evaluation of metals in the edible portion, but added an analysis of metals in liver tissue and an analysis of polychlorinated biphenyls (PCB) and pentachlorophenol (PCP) in the edible portion and reproductive tissues. The liver tissue was included to provide data on the extent of contaminant migration into the fish (liver tissue is known to accumulate metals).

Iron was not recommended in the original work plan as it is a major constituent in vertebrate blood and is differentially distributed in tissues. Lead was dropped from the work plan analysis list as it was not found in significant amounts in the water analyses.

Additionally, the consensus plan included an analysis of PCB and PCP in fish tissue. These organic parameters were included because Silver Bow Creek was known to receive wastes containing PCP and potentially had received PCB from within the drainage area. Muscle tissue was selected for PCB and PCP analysis, as this is the tissue most often consumed by people. Reproductive tissue was selected for PCB and PCP analysis, as these tissues are high in fats (which are known to accumulate organic pollutants).

The final objectives of the SBC RI Fish Tissue Investigation were as follows:

- Assess metal contamination in the edible portion and livers of fish residing in the Warm Springs Ponds.

- Assess PCB and PCP contamination in the edible portion and reproductive tissue of fish residing in the Warm Springs Ponds.

1.2 HISTORICAL DATA

The fisheries resource of the Silver Bow Creek/Upper Clark Fork River system ranges from non-existent to fairly good.

Based on a review of available literature and site observations, Silver Bow Creek from Butte to Warm Springs appears to have no viable fishery. The Warm Springs Ponds and the upper Clark Fork River both have adequate fisheries, mostly brown trout (Salmo

trutta) (Hadley 1984). Fish in the Warm Springs Ponds are found in The Wildlife Ponds (Island Pond and Hog Pond), the drains from these ponds, the decant tower drain, and probably Pond No. 2 (Hadley 1986). The upper Clark Fork River from the Warm Springs Ponds to Bearmouth (west of Drummond) is classified as a high-priority fishery resource (MDFWP 1980).

The tributaries of Silver Bow Creek proper have not been systematically inventoried for their fisheries (MDFWP 1980; Holton 1983; Munther 1983; and Walsh 1983). However, Basin Creek is known to have at least a marginal fishery of brook trout (Salvelinus fontinalis) (Konizeski 1978), and Blacktail Creek probably contains some brook trout as well. Tributaries to Silver Bow Creek in the upper Deer Lodge valley -- German Gulch, Willow Creek, and Mill Creek -- have good fisheries resources (MDFWP 1980).

In spite of its high priority classification, the upper Clark Fork River appears to have some problems due to contamination of the aquatic system. Phillips (1983) indicated that copper concentrations in winter and spring may be limiting fish productivity by depressing reproduction and affecting larval survival of trout. Hadley (1984) indicated that fish populations are high just below major "clean" tributaries.

Past studies on the fisheries of the Silver Bow Creek/Upper Clark River System have included bioassay studies on the discharge from the Warm Springs Ponds and fish tissue studies on the upper Clark

Fork River (EG&G 1979; EG&G 1978; Phillips 1982; Dent 1975; Van Meter 1974).

The fisheries in the upper Clark Fork River were investigated for metals residues in muscle tissue by Phillips (1982), Van Meter (1974), and Dent (1975). They found that none of the fish muscle tissue tested had metal residues high enough to constitute a hazard to human health, as compared to the U.S. Department of Agriculture action levels in beef, swine, or poultry. Conclusions of Phillip's (1982) study were as follows: (1) mercury concentrations appeared to be higher in downstream samples than in samples from near the Warm Springs Ponds; (2) poor reproducibility of duplicate analyses for copper, cadmium, and lead indicate a problem with sample matrix; and (3) if the intent of a study is to document metal exposure of a fish, then the best tissues to analyze would be the liver and gill.

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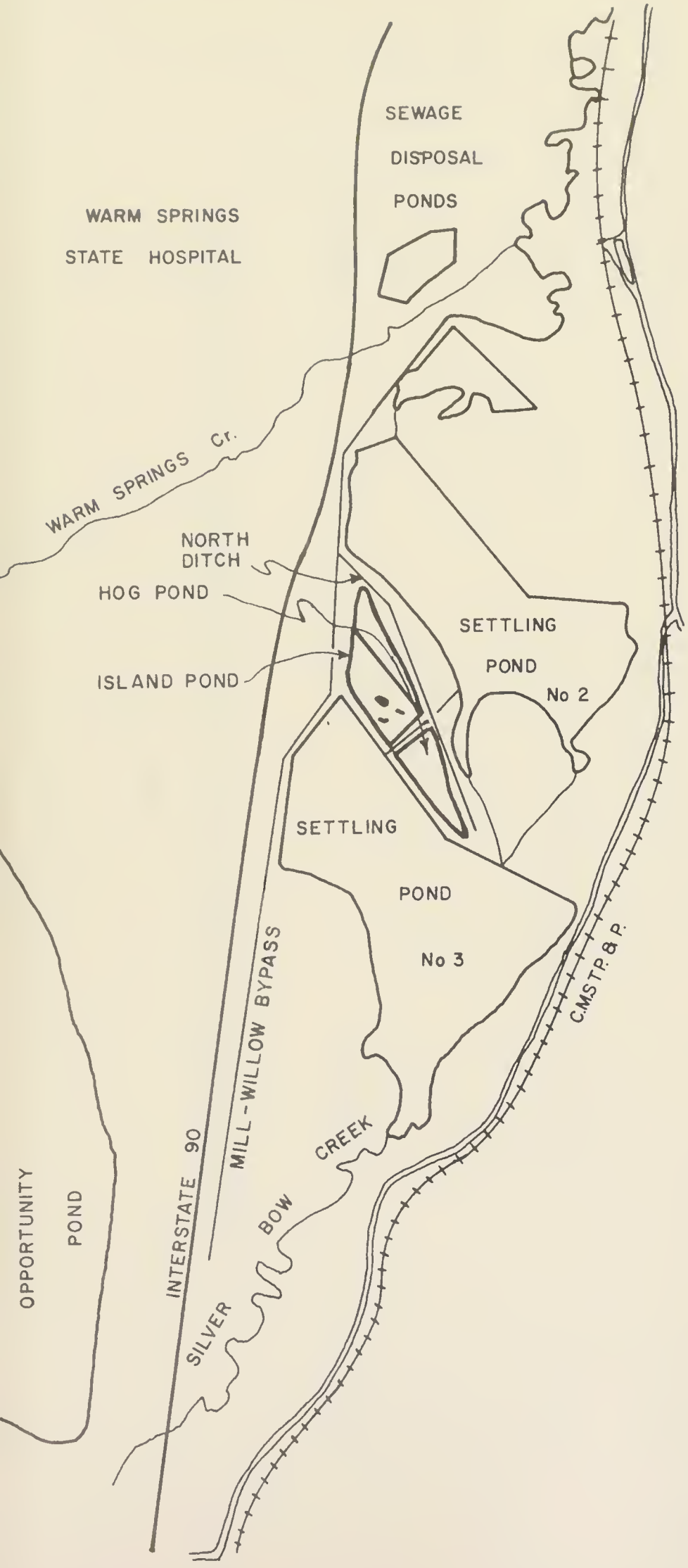
2.0 METHODS

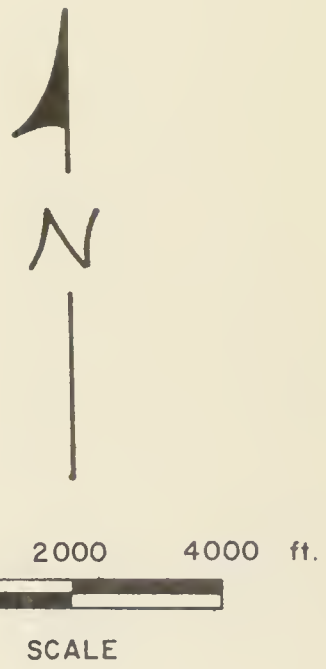
2.1 LOCATION OF SAMPLING SITES

Samples were collected from the wildlife ponds located within the Warm Springs Ponds System. Map 1-1 shows the location of the Warm Springs Ponds within the Silver Bow Creek Site, and Map 2-1 shows the Warm Springs Ponds area in more detail. Table 2-1 lists the sampling sites for each sample taken.

2.2 SAMPLE COLLECTION

Fish were taken by personnel of the Montana Department of Fish, Wildlife, and Parks (MDFWP) using a gill net. After collection, the samples were put in large plastic bags, labeled, and placed in a freezer at the facilities of the Warm Springs Wildlife Management Area. Sampling dates, weight, and sex are presented in Table 2-1. MultiTech laboratory personnel transported the samples from the Warm Springs Wildlife Management Area to Butte. The samples were logged in, assigned sample numbers, and placed into laboratory freezers in the sample bank area.





SILVER BOW CREEK

REMEDIAL INVESTIGATION

MAP 2-1

WARM SPRINGS PONDS

TABLE 2-1

COLLECTION DATE, COLLECTION LOCATION, LAB NO., SEX, AND WEIGHT
OF RAINBOW TROUT COLLECTED FOR THE SBC RI FISH TISSUE INVESTIGATION

DATE	LOCATION	LAB NO.	SEX	WEIGHT[a]
7/7/85	Hog Pond	T049	Male	1399
7/7/85	Hog Pond	T050	Male	1195
8/21/85	West Decant Ditch	T051	Female	1475
8/27/85	Drain Ditch from Island Pond to N. Drain	T052	Male	1712
8/27/85	"	T053	Male	2424
8/27/85	"	T054	Female	1324
8/27/85	"	T055	Male	1145
8/27/85	"	T056	Male	1404
8/27/85	"	T057	Male	1343
8/27/85	"	T058	Female	2302

(a)Wet Weight in gms.

2.3 SAMPLE PREPARATION

2.3.1 Sample Preparation For Metals Analysis

Samples initially were prepared according to the following protocol:

(1) Remove fish from the laboratory freezer and partially thaw at room temperature in their plastic wrappings.

(2) Unwrap carcass and weigh to the nearest gram.

(3) Clean labware - for each fish, before dissection:

(a) rinse plastic wash basin with tap water, wash with 10% nitric acid, and rinse with de-ionized water.

(b) Wash Teflon® coated instruments with Liquinox®, rinse with tap water, followed by 10% nitric acid, and finally by de-ionized water.

(c) Wash metal instruments not coated with Teflon® with Liquinox® and rinse with de-ionized water. Do not use nitric acid on uncoated metal instruments.

(4) Place fish in plastic wash basin and remove a square fillet of muscle and skin. Open the body cavity of each fish with a mid-ventral cut using surgical scissors. Remove the liver and reproductive tissue (eggs or testes); place each tissue in a labeled plastic Whirlpak® and store in laboratory freezer.

(5) Save remaining carcass and place in laboratory freezer.

Dissected tissues were digested prior to metals analysis according to the following protocol:

(1) Remove tissue sample (muscle, liver, etc.) from the freezer, thaw partially, cut in half, and remove approximately 4 gm (wet weight) from the inside of one of the halves. Weigh to the nearest 0.01 gm. Place in an Erlenmeyer flask.

(2) Add 2 ml of concentrated H_2SO_4 and 3 ml of concentrated HNO_3 to the flask and heat (but do not boil) until HNO_3 is evaporated (as indicated by the presence of dense, white SO_3 vapor).

(3) Remove flask from the heat and wash the sides with deionized water. Add 3 ml concentrated HNO_3 and 1 ml 30% H_2O_2 and reheat the flask (no boiling).

(4) While being heated, add 3 ml concentrated HNO_3 and 1 ml 30% H_2O_2 five times.

(5) Heat until nitric acid is removed, cool, and bring to 50 ml in a volumetric flask with deionized water.

The protocol used deviated from the sample-preparation protocol found in the SBC RI Work Plan in three aspects:

- Dissection occurred after freezing and partial thawing of the whole fish, rather than on the day of collection;

- Dissection tools were not washed between tissues;

- Samples were not homogenized prior to digestion, but the whole section was placed in the acid solution.

The first deviation has no effect on data validity, as the metals of interest in the tissues are not transportable while the tissues are frozen. Not washing the tools during dissection on a single fish has no effect on data validity, as the only contaminant between tissues was the blood of the individual fish, which is homogeneous in nature and occur in large quantities within each tissue. Homogenization of tissues was specified to facilitate digestion; experience showed that the samples could be digested without this step, and eliminating this step removed a potential point of contamination.

2.3.2 Sample Preparation For PCP and PCB Analysis

Dissection for the pentachlorophenols (PCP) and polychlorinated biphenyls (PCB) tissue analysis was performed in the same way as for the metals samples. Tissue samples for organics were stored and shipped in metal foil. PCP sample extraction was performed as described in Characterization of Hazardous Waste Sites, a Methods Manual, Volume 3 - Available Laboratory Analytical Methods: "Analysis of Biological Tissue Samples for Acid Extractable Organic

Compounds by Methylene Chloride Extraction" (USEPA 1984). PCB sample extraction was performed as described in the same manual, "Analysis of Biological Tissues for Pesticides/Polychlorinated Biphenyls" (USEPA 1984).

2.4 SAMPLE ANALYSIS

2.4.1 Sample Analysis for Metals

The digestion solutions resulting from sample preparation were analyzed for arsenic (As) and cadmium (Cd) by flameless atomic absorption technique. Arsenic was analyzed using a hydride-vapor generation technique as described by USEPA Method 206.3 (USEPA 1983). Cadmium was analyzed by furnace using EPA Method 213.2 (USEPA 1983). Copper and zinc were analyzed by ICAPES as described by USEPA Method 200.7 (USEPA 1983).

2.4.2 Sample Analysis for PCP and PCB

The extraction solution was analyzed for PCP by EPA Method 604 (USEPA 1982) and PCB by EPA Method 608 (USEPA 1982).

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3.0 DATA ANALYSIS AND INTERPRETATION

3.1 METALS DATA

Four male and one female rainbow trout (Salmo gairdneri) were analyzed for arsenic (As), cadmium (Cd), copper (Cu), and zinc (Zn) in muscle fillets and liver tissues. All five fish were collected from the Warm Springs Ponds. Table 2-1 lists the location of collection and weight of each fish. Table 3-1 lists the means, standard errors, and ranges of concentrations found in the tissues analyzed. Analysis data for each fish are presented in Attachment I, Tables I-1, I-2, I-3, and I-4 for arsenic, cadmium, copper, and zinc, respectively. These tables also present accompanying quality assurance and quality control data.

3.1.1 Quality Assurance and Quality Control Considerations

The Silver Bow Creek Remedial Investigation (SBC RI) Quality Assurance and Quality (QA/QC) Control Plan (MultiTech and Stiller and Associates 1984b) and the SBC RI Work Plan (MultiTech and Stiller and Associates 1984a) were followed for the study except as previously noted in Section 2.0 regarding sample preparation.

The QA/QC Plan requires the following: (1) analysts' calibration checks, replicates, and spikes to be performed at a frequency of 10% and to be within specified control limits; (2) blind (sample bank) solution standards, digestion standards, digestion spikes,

TABLE 3-1

MEANS, STANDARD ERRORS, AND RANGES OF ARSENIC, CADMIUM, COPPER AND ZINC IN WARM SPRINGS PONDS FISH TISSUES COMPARED TO STANDARDS FOR THESE METALS IN FOOD

	N	Mean[a,b]	Standard Error[a,b]	Range[a]	Standard[a]
Arsenic					
Muscle[c]	5	0.103	0.034	<0.055 - 0.235	0.70[e], .50[f] µg/g
Muscle[d]	5	0.143	0.058	<0.143 - 0.146	
Liver[c]	5	0.122	0.067	<0.055 - 0.390	
Liver[d]	5	0.188	0.074	<0.144 - 0.455	
Cadmium					
Muscle[c]	5	0.033	0.014	0.01 - 0.089	400 - 500 µg/week[g]
Muscle[d]	5	0.101	0.018	<0.082 - 0.174	
Liver[c]	5	1.58	0.356	0.688 - 2.51	
Liver[d]	5	0.788	0.286	<0.083 - 1.54	
Copper					
Muscle[c]	5	0.558	0.089	<0.325 - 0.838	100[h]
Liver[c]	5	288	114	104 - 738	
Zinc					
Muscle[c]	5	5.06	0.519	3.74 - 6.18	100[h]
Liver[c]	5	46.4	5.12	32.2 - 62.2	

(a) µg/g
(b) Mean and Standard Error based on <DL reported at the DL
(c) First run
(d) Second run
(e) Maximum allowed by USDA/APHIS meat inspections in cattle (USDA No Date)
(f) Maximum allowed by USDA/APHIS meat inspections in swine (USDA No Date)
(g) Provisional tolerable weekly intake (FAO/WHO 1972)
(h) Canadian Food and Drug Directorate (Phillips 1982)

and digestate splits at a frequency of one in forty; and (3) blind (sample bank) digestion blanks and tissue splits at a frequency of one in twenty.

Method Detection Limits (MDL = three times the standard deviation of replicate determinations of a calibration blank) were experimentally determined for each batch of analyses and are reported as determined, including corrections for variations in sample weight and final digestate volume. Samples for which relatively little tissue was available showed a concomitantly larger MDL. Analysts' replicates, calibration checks, and spikes indicate the accuracy and precision of post-digestion steps in the analysis. Sample bank standards, spikes, blanks, and duplicates indicate the cumulative accuracy and precision of the post-digestion steps and all other steps included in the preparation of the particular sample bank sample.

Review of these data shows that the precision and accuracy of the analysis at the instrument was good, with the duplicate sample agreement/replicate sample agreement (DSA%/RSA%), known sample agreement (KSA%), and spike sample recovery (SSR%) values well within the limits set by the SBC RI QA/QC plan. The QA/QC data indicate that values reported are sufficiently accurate and precise for comparison to food standards. DSA%, RSA%, KSA%, and SSR% formulae are presented in Table I-1.

Each metal's unique QA/QC factors are discussed in the following subsections.

3.1.1.1 Arsenic QA/QC

Sample bank sample Q965 (EPA metals in fish tissue) showed a KSA% for arsenic of 5%, indicating incomplete recovery. However, sample bank sample Q966 (NBS metals in bovine liver) showed a KSA% of 163%. Because these two samples had conflicting data, all samples were redigested and re-analyzed for arsenic. Tissue for the second digestions were taken from fillets that were dissected with the original analytical samples and stored in the freezer; the second set was digested in the same manner as the first set. New Q-samples also were prepared. Both sets of data are presented in Table I-1. As shown in this table, Q966 had a high KSA% on the second digestion and analyses, indicating a continuing problem with that particular sample matrix. However, Q965 showed a KSA% of 101, indicating good arsenic recovery.

DSA%s were calculated for the samples between the two runs (see Attachment Table I-1). For those samples which were greater than the MDL, the DSA% ranged from 76% to 150%. Within the same run the DSA% ranged from 74% to 100%. These DSA% reflect the precision of the method of analysis and the heteorogeneity of the tissues analyzed.

Analyst-level QA/QC data easily came within the required ranges, indicating that the major factors affecting the method's precision and accuracy were digestion related.

3.1.1.2 Cadmium QA/QC

Sample bank samples Q965 (USEPA metals in fish), Q966 (NBS metals in bovine liver), and Q967 (USEPA metals in water) in the first digestion and analysis for cadmium showed conflicting data regarding cadmium recovery (see Attachment Table I-2). Due to the conflicting data, cadmium was re-analyzed with arsenic in the second digestion. These data also are presented in Attachment Table I-2. As seen in this table, the second digestion and analysis showed improved KSA%s for the sample bank standards.

DSA%s between the first run and second run for samples greater than the detection limit ranged from 48% to 180%. Within a run, the sample bank duplicate DSA% ranged from 91% to 175% for run one and was 100% for run two. These DSA%s reflect the precision of the digestion and analysis and the heterogeneity of the tissues sampled.

Analyst replicate, spike, and standard data indicate the major factors affecting the precision and accuracy of the measurement of cadmium in fish tissue were digestion related.

3.1.1.3 Copper QA/QC

No conflicting QA/QC data were found for the analysis of copper from the first digestion, so copper was not re-analyzed in the second digestion (see Attachment Table I-3). Sample bank KSA%s ranged from 92% to 105%, sample bank DSA%s ranged from 92% to 146%, and the sample bank spike recovery was 100%. Analyst QA/QC data were all within the required range.

3.1.1.4 Zinc QA/QC

No conflicting QA/QC data were found for the analysis of zinc from the first digestion, so zinc was not re-analyzed in the second digestion (see Attachment Table (I-4). Sample bank KSA%s ranged from 95% to 109%, sample bank DSA%s ranged from 100% to 104%, and the sample bank spike recovery was 112%. Analyst QA/QC data were all within the required range.

3.1.2 Arsenic

Attachment Table I-1 shows that arsenic was detected in three of five muscle samples and one of five liver samples in the first analysis run when the method detection limit was 0.055 µg/g. In the second analysis run, when the method detection limit was 0.144 or 0.143 µg/g, only one of five muscles showed detectable levels of arsenic and two of four livers showed detectable levels of arsenic. (Only four liver samples had enough sample left for redigestion.)

The means, standard errors, and ranges for arsenic in Warm Springs Ponds fish tissues are compared to USDA swine and poultry standards for arsenic in Table 3-1. These standards are shown for comparison only. The USDA does not regulate arsenic in fish (Spaulding 1986) and neither does the U.S. Food and Drug Administration (Campbell 1986). Both analyses runs of arsenic show that TO51 had the highest levels of arsenic found in muscle tissue, 0.235 and 0.146 µg/g for runs one and two, respectively. Both of these values are below the USDA's lowest standard for arsenic in swine and poultry of 0.50 µg/g (USDA No Date). TO51 also had the highest values for arsenic in liver tissue, with reported concentrations of 0.390 and 0.455 µg/g for runs one and two, respectively. These values are lower than the USDA standard of 2.00 µg/g, for livers of swine and poultry (USDA No Date).

Attachment II shows examples from the literature for metals and organics concentrations in fish tissue. Lowe, et al. (1985) analyzed fish muscle tissue from various regions of the United States in 1978-1979 and again in 1980-1981. Their data are presented in Attachment Table II-5. Average (geometric mean) concentrations of arsenic measured by Lowe, et al. (1985) were 0.16 and 0.14 µg/g for 1978-1979 and 1980-1981, respectively. The Warm Springs Ponds geometric means of arsenic concentration in fillets of 0.08 and 0.14 µg/g (for runs one and two, respectively) are close to these natural values, indicating arsenic in Warm Springs Ponds fish fillets probably are not elevated above natural levels.

Attachment Table II-1 gives other examples of arsenic concentrations in fish tissue for comparison. These data also show values for concentrations of arsenic in muscle tissue similar to those found in Warm Springs Ponds fish fillets.

Attachment III contains historic data for metals and organics concentrations in Clark Fork River fish. Table III-1 shows metals data reported by Neher and Weisel (1977) for a single brown trout fillet collected from Warm Springs Pond No. 3. A concentration of 0.51 µg/g wet weight was reported for arsenic in this one sample. This concentration is higher than any value found in the SBC RI study and is above the 0.5 µg/g standard for arsenic in swine (USDA No Date).

Phillips (1982) studied metal concentrations in the fillets of brown trout (Salmo trutta) in the Clark Fork River below the Warm Springs Ponds. His data are summarized in Attachment Table III-4. Phillips found that arsenic concentrations ranged from 0.01 µg/g to 0.83 µg/g, with averages for Age Class I, Age Class II, Age Class III, and Age Class IV ranging from 0.10-0.16 µg/g, 0.08-0.15 µg/g, 0.05-0.28 µg/g, and Not Detectable-0.18 µg/g, respectively, for three different reaches of the river. Fish from the Warm Springs Ponds tested for this study did not show arsenic concentrations in their muscle that appeared to be higher than those reported by Phillips (1982).

Attachment Table III-5 gives the concentrations of arsenic measured in the discharge from the wildlife ponds. Attachment Figure III-1 graphs this information. These data are indicative of the concentrations of arsenic to which the fish measured for arsenic were exposed prior to their collection. Only T051 was collected in water not represented by this water quality data.

Excluding T051 data (both fillet and liver), the fish tested for arsenic concentrations are not significantly accumulating arsenic above exposure concentrations. Water quality data for arsenic for the water to which T051 was exposed is reported in Attachment Table III-6. This individual fish appears to be concentrating arsenic approximately ten times over the ambient water concentrations. Since this was the only female tested, sex may be a contributing factor, but these small sample sizes are insufficient to evaluate concentration differences due to sex. Spehar, et al. (1980) found that rainbow trout (Salmo gairdneri) exhibited an arsenic bioconcentration factor of zero when exposed to arsenic trioxide, and the USEPA (1978) found that bluegills (Lepomis macrochirus) exhibited an arsenic bioconcentration factor of four when exposed to arsenic trioxide.

Arsenic does not appear to be differentially distributed between the two tissues tested. Muscle concentrations and liver concentrations in the first analysis run ranged from <0.055-0.235 µg/g and <0.055-0.390 µg/g, respectively and ranged from <0.143-0.146 µg/g and <0.144-0.455 µg/g, respectively for the second analysis run.

Arsenic and cadmium concentrations were in the same range, but copper and zinc concentrations in both muscle tissue and liver tissue were 100 to 1000 times greater than arsenic concentrations.

3.1.3 Cadmium

Cadmium was detected in all five muscle and all five liver tissues tested in digestion and analysis run one (Attachment Table I-2). The lowest detected value in run one was 0.010 µg/g. In digestion and analysis run two only one muscle showed detectable levels of cadmium and four of five liver tissues showed detectable levels (the MDL for run two was 0.083 µg/g).

The means, standard errors, and ranges for cadmium in Warm Springs Ponds fish tissues are compared to food standards for cadmium in Table 3-1. The FAO/WHO standard for cadmium is 400-500 µg/week (FAO/WHO 1972). For the worst-case muscle tissue (0.174 µg/g) found, 287g per week (6.33 lbs/week) would have to be consumed to reach 500 µg/week of cadmium. For the worst-case liver tissue, 199g per week (0.44 lbs/week) would have to be consumed to reach 500 µg/week of cadmium. The Food and Drug Administration does not regulate cadmium concentrations in fish (Campbell 1986) and the USDA does not regulate cadmium in other meat such as cattle, swine, or poultry (Spaulding 1986).

Lowe, et al. (1985) measured background concentrations of cadmium in fish muscle tissue in the United States (Attachment Table II-5) and reported geometric means of 0.04 and 0.03 µg/g wet weight for 1978-1979 and 1980-1981, respectively. Ranges reported by Lowe, et al. (1985) for cadmium concentrations were 0.01-0.41 and 0.01-0.35 µg/g, respectively. Data for cadmium concentrations in fillet tissue of Warm Springs Ponds fish are in the same range as these, indicating cadmium is not concentrating in the muscle tissue of the Warm Springs Ponds fish above natural levels.

Dent (1977) reported the mean cadmium concentration in the muscle tissue of 10 brown trout (Salmo trutta) taken from Rock Creek, a relatively pristine tributary to the Upper Clark Fork River, to be 0.040 µg/g wet weight. The means for cadmium concentrations in Warm Springs Ponds fish fillets were 0.033 and 0.101 µg/g, for runs one and two respectively. These data also suggest that Warm Springs Ponds fish are not concentrating cadmium in their fillets above naturally occurring levels.

Attachment Tables III-1, III-2, and III-3 present additional data on cadmium concentrations in fish of the Clark Fork drainage and the Warm Springs Ponds. Dent (1977) reported a cadmium concentration of <0.05 µg/g wet weight in the muscle of a single brown trout collected from Warm Springs Pond No. 3 in 1976 (Table III-1), which is in the same range as measured in this study.

Van Meter (1974) reported mean muscle and liver cadmium concentrations of 0.19 and 0.69 µg/g wet weight, respectively, for trout (Salmo spp.) from the Clark Fork drainage. Van Meter (1974) also reported mean cadmium concentrations in trout liver from selected portions of the Clark Fork drainage. For that portion of the river just below the Warm Springs Ponds, he reported mean liver concentrations of cadmium of 1.1 µg/g wet weight. Van Meter (1974) also reported a mean cadmium concentration in the livers of Rock Creek trout of 1.9 µg/g wet weight. His drainage-wide means are in the same range as the means generated by this study. Of special interest is the cadmium concentration in the livers of Rock Creek trout, which was higher than either of the means generated by this study for Warm Springs Ponds trout. Since Rock Creek is a relatively pristine aquatic system, these data suggest Warm Springs Ponds trout are not accumulating greater amounts of cadmium in their livers than are fish in less impacted drainages.

Additional literature data on cadmium concentrations in fish tissue are presented in Attachment Table II-2. Kneip and Hazen (1979) studied cadmium in the biota of Foundry Cove, New York, an area impacted by cadmium contamination. They found mean concentrations of cadmium fish edible portions from their study area to be 0.15 µg/g, not much greater than natural levels. They also found that mean cadmium concentrations in liver tissues were much higher than mean edible portion concentrations (7.2 µg/g vs. 0.15 µg/g). Warm Springs Ponds fish showed this same pattern, but not as strongly (1.58 vs. 0.033 µg/g in run one and 0.788 vs. 0.101 µg/g in run two). These

data suggest Warm Springs Ponds fish are concentrating cadmium differentially in fillet and liver tissues.

Phillips (1982) measured cadmium concentrations in the muscle tissue of brown trout (Salmo trutta) from the Clark Fork River below the Warm Springs Ponds. Age Classes I, II, III, and IV had mean cadmium concentrations of 0.05-0.43, 0.07-0.56, 0.09-1.20, and 0.22-0.83 µg/g, respectively for three sections of the river. The two means calculated for cadmium in Warm Springs Ponds fish fillets are within these ranges, indicating that fish from the ponds are not carrying heavier cadmium loads in their muscle tissue than fish from the river below the ponds. Phillips (1982) did not analyze liver tissue, so those tissue concentrations cannot be compared.

Attachment Table III-5 gives the concentrations of cadmium measured in the discharge from the wildlife ponds. Attachment Figure III-2 graphs this information. As seen in these data, cadmium was consistently below detection limits in the water of the wildlife ponds discharge (MDLs ranged from <0.00025-<0.0015 mg/L). These values are considerably lower than the values measured in the fish tissue, indicating that even if the tissue concentrations of cadmium in Warm Springs Ponds fish are not above tissue concentrations exhibited by fish living in pristine waters (Rock Creek - Dent 1977), the fish are concentrating cadmium from ambient exposure. As shown in Attachment Table II-8, this is common with experimentally derived concentration factors for cadmium, ranging from 3-540 for salmonids (USEPA 1980).

Cadmium and arsenic showed similar concentration ranges in both fillet and liver tissue in fish from the Warm Springs Ponds. Copper and zinc showed concentrations in fillet and liver tissues 100 to 1000 times greater than cadmium concentrations.

3.1.4 Copper

Copper was detected in nine of ten issues analyzed (Attachment Table I-3). Means, standard errors, and ranges of copper concentrations in the fillets and livers of the five fish tested are presented in Table 3-1, along with standards for copper in food. The five fillets tested showed a concentration range of <0.325 to 0.838 µg/g, considerably less than the 100 µg/g standard set by the Canadian Food and Drug Directorate (Phillips 1982). The five liver tissues showed a range of copper concentrations of 104-738 µg/g, considerably higher than the standard. The USDA does not regulate copper in cattle, swine, or poultry (Spaulding 1986) and the FDA does not regulate copper in fish (Campbell 1986).

Table II-5 shows the data of Lowe, et al. (1985) who studied metals concentrations in fish in the United States. He found that mean background levels of copper in fish muscle was 0.86 and 0.68 µg/g for 1978-1979 and 1980-1981, respectively. These data indicate that concentrations of copper in Warm Springs Ponds fish fillets are probably not above natural concentrations of copper in fish fillets. Table II-3 presents some data for copper in fish tissues from the literature. Using an estimated dry weight to wet weight

conversion factor of 0.20 (Phillips 1982) to change some of the literature data yields values for copper concentrations in fish muscle similar to those reported in this study. These data support the preliminary conclusion that copper concentrations in fillets from the Warm Springs Ponds are not elevated above naturally occurring concentrations.

Dent (1977) and Van Meter (1974) reported mean copper concentrations in fish tissues from Rock Creek, a relatively pristine tributary to the Clark Fork River. Dent (1977) reported a mean muscle concentration of copper of 1.366 µg/g wet weight and Van Meter (1974) reported a mean copper liver concentration of 17 µg/g wet weight. These data suggest that copper is not found above naturally occurring concentrations in Warm Springs Ponds fish muscle tissue, but is found at higher than naturally occurring concentrations in liver tissue.

Dent (1977) also reported a copper concentration of 0.82 µg/g wet weight in the muscle tissue of a single brown trout (Salmo trutta) collected from Warm Springs Pond No. 3 in 1976. The muscle fillet copper concentrations in the fish collected for this study were found to be near this value.

Phillips (1982) reported copper concentratons in fish muscle of the upper Clark Fork River below the Warm Springs Ponds. For age Classes I, II, III, and IV, Phillips (1982) reported mean muscle copper concentrations of 0.15-0.25, 0.2-0.15, 0.12, and 0.250.28 µg/g

wet weight, respectively for three different reaches of the stream. These values are slightly lower than the ranges reported for copper in Warm Springs Pond's fish fillets (<0.325-0.838) but are probably not significantly lower. Phillips (1982) data are summarized in Attachment Table III-4.

Attachment Table III-5 and Figure III-3 present the total copper concentrations in the water of the discharge from the wildlife ponds from December 5, 1984 to August 29, 1985. The highest total concentration reached during this period was 0.072 mg/L. The concentration factors for mean total copper water concentration versus mean copper muscle and liver concentrations are 16.4 and 8470, respectively, indicating copper is being concentrated in Warm Springs Ponds fish tissues. Because copper is a required element in animal nutrition, the significance of copper residues has not been established, and few tests have been run for the purpose of determining bioconcentration factors (USEPA 1980).

These data also indicate that copper in Warm Springs Ponds fish is differentially distributed between the two tissues tested. Copper appears to be found at much higher concentrations than arsenic and cadmium in the tissues tested. Copper appears to be lower than zinc in muscle tissue, but higher than zinc in liver tissue.

3.1.5 Zinc

Zinc was detected in all 10 fish tissues tested. Zinc concentrations in muscle and liver tissue averaged 5.06 and 46.4 µg/g wet weight, respectively, and ranged from 3.74-6.18 and 32.2-62.2, respectively. All 10 tissues tested showed concentrations lower than the Canadian Food and Drug Directorate standard of 100 µg/g (Dent 1977). The USDA does not regulate zinc in cattle, swine, or poultry (Spaulding 1986), and the FDA does not regulate zinc in fish (Campbell 1986).

Lowe, et al. (1985) reported background levels of zinc in fish muscle of the United States to have a geometric mean of 25.63 and 23.82 µg/g wet weight (Attachment Table II-5). Warm Springs Ponds fish fillets had a geometric mean zinc concentration of 4.95. These data suggest that fish in the Warm Springs Ponds are not accumulating zinc in their fillets at higher than naturally occurring concentrations. Additional literature data on zinc concentrations in fish tissue presented in Attachment Table II-4 support this conclusion.

Van Meter (1974) reported mean muscle and liver concentrations of zinc in trout from the Clark Fork Drainage (below the Warm Springs Ponds and including tributaries) to be 6.3 and 38 µg/g wet weight (Attachment Table III-2). These concentration values appear to be similar to the concentration values found in Warm Springs Ponds fish. Dent (1977) reported mean zinc concentration in Rock Creek

muscle to be 7.036 µg/g wet weight. These data support the observation that zinc is not accumulating at greater than naturally occurring concentrations in Warm Springs Pond fish muscle.

Phillips (1982) reported that mean zinc concentrations in the muscle of Age Classes I, II, III, and IV brown trout (Salmo trutta) had ranges of 4.45-4.85, 3.55-4.15, 3.69-4.63, and 3.52-3.92 µg/g wet weight, respectively, for three sections of the upper Clark Fork River. Warm Springs Ponds fish, with a mean zinc concentration in their fillets of 5.06 µg/g wet weight, appear not to be different from the fish in the river below the ponds.

Zinc concentrations in the water of the discharge from the wildlife ponds for December 5, 1984 through August 29, 1985 are reported in Attachment Table III-5 and graphed in Attachment Figure III-4. A peak total zinc concentration of 0.250 mg/L occurred on February 13, 1985, but base-flow concentrations appear to be around 0.020 mg/L. Fish in the Warm Springs Ponds appear to be significantly concentrating zinc in both their muscle and liver tissues. The most conservative concentration factors (using the peak water concentration and mean tissue concentrations) were 20.2 and 185.6 for muscle and liver tissue, respectively. These concentration factors compare to a Zn muscle concentration factor of 25 reported by Renfro et al. (1975), of 51 reported by Farmer, et al. (1979) for whole bodies of Atlantic salmon (Salmo salar), and of 432 reported by Spehar, et al. (1978) for whole bodies of flagfish (Jordanella floridae).

Zinc appears to be differentially distributed between the two tissues tested, showing greater concentrations in the livers than in the fillets. Zinc appears to be higher in concentration in both muscle and liver tissue than arsenic or cadmium. Copper appears to be more concentrated in Warm Springs Ponds fish livers than zinc, but appears to be less concentrated in muscle.

3.2 PCP AND PCB DATA

Two male and three female rainbow trout (Salmo gairdneri) were analyzed for pentachlorophenol (PCP) and polychlorinated biphenyls (PCB) in fillets and reproductive tissues. All five fillets tested showed detectable levels of PCP and PCB. All five reproductive tissues tested showed detectable concentrations of PCP, and four of the five showed detectable concentrations of PCBs.

3.2.1 Quality Assurance and Quality Control Considerations

3.2.1.1 PCP QA/QC

Attachment Table I-5 presents the analysis data and QA/QC data for the PCP analyses of Warm Springs Ponds fish tissues. The Sample Bank blank (Q970) indicated no contamination, showing a value of PCP <0.005 ppm. Method precision was documented with the Sample Bank duplicate (Q972), which had a DSA% of 114%. Method accuracy was measured with a Sample Bank standard (O974) which had a KSA% of 35%. This low KSA% indicates low recovery of PCP in the O-sample,

which may mean low recovery in the study samples. If this is true, PCP data presented may be only 35% of actual PCP concentrations.

3.2.1.2 PCB QA/QC

Attachment Table I-6 presents the analysis data and QA/QC data for the PCB analysis of Warm Springs Ponds fish tissue. Potential contamination was tested with Sample Bank sample Q971, which showed <0.0004 mg/sample. Method precision was measured with Q973 which showed a wet weight DSA% of 54% and a lipid based DSA% of 98%, reflecting the fat affinity of PCBs and the heterogenous distribution of fat in tissue. Method accuracy was measured with Sample Bank sample Q975, which showed a KSA% of 69%, indicating sample data may be only 69% of actual concentrations.

3.2.2 PCP

Pentachlorophenol (PCP) has been listed by the USEPA as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) of 1976. PCP was selected for analysis in fish tissue for the SBC RI as Silver Bow Creek is known to receive PCP-bearing oil from an abandoned post and pole treatment plant. This analysis was done as part of the SBC RI. Subsequently, the post and pole treatment plant was proposed as a separate "CERCLA" site.

Table 3-2 shows the means, standard errors, and ranges of PCP concentrations in Warm Springs Ponds fish tissues tested. Attachment

TABLE 3-2
MEANS, STANDARD ERRORS AND RANGES OF PCP IN WARM SPRINGS PONDS
FISH FILLETS AND REPRODUCTIVE TISSUES

	Mean[a]	Standard Error[a]	Range[a]
PCP in fillet	0.015	0.0029	0.008-0.024
PCP in fillet-lipid basis	0.495	0.0732	0.301-0.728
PCP in reproductive tissue[b]	0.0308	0.0086	0.008-0.054
PCP in reproductive tissue-lipid basis[b,c]	2.63	1.03	1.04-6.58

(a) All values in ppm wet weight.

(b) Reproductive tissue includes female eggs and male testes.

(c) ppm PCP on lipid basis calculated as $\frac{\text{mg PCP in Tissue}}{\text{kg lipid in Tissue.}}$

Table I-5 shows the analysis data and QA/QC data for the tissues tested for PCP. Attachment Table III-7 presents the water quality data for PCP collected as part of the SBC RI. These data are compared to a proposed water quality criterion for PCP. The water quality data for PCP was collected upstream and downstream of the known point source of PCP. The lowest downstream site sampled for PCP was SS-07, which is 22.3 stream miles above the Warm Springs Ponds.

As seen in Table III-7, the proposed water quality criterion for PCP was exceeded at the stations sampled on several occasions. However, no PCP water quality data were collected for stations nearer the Warm Springs Ponds. Comparisons of the available water quality data to the fish data do not provide much insight. More extensive PCP water quality data were not collected at the Warm Springs Ponds because the first approach was to document tissue concentrations, before embarking on a pathway study. The Fish Tissue Investigation was to serve as documentation of tissue concentrations.

Fish tissues from the Warm Springs Ponds had measurable amounts of PCP on a wet weight basis and on a lipid basis (Table 1-5). The USEPA has a draft One-Day Health Advisory (HA) for PCP calculated for a 10 kg (22 lb) child as follows (USEPA 1985):

$$\text{One-Day HA} = \frac{(\text{NOAEL})(\text{BW})}{(\text{UF})\ (\text{L/day})} = \mu g/L$$

where

NOAEL = No Observed Adverse Affect Level (The exposure done in mg/kg BW)

BW = Body weight in Kg

UF = Uncertainty Factor

L/day = Assumed daily water consumption.

$$\text{One-Day HA} = \frac{(10\ \text{mg/kg/day})\ (10\ \text{mg})}{(100)\ (1\text{L/day})}$$

Using the data provided in these equations one can calculate (using the UF of 100) that the daily HA intake equals 1.0 mg/day for a 10 kg child.

Using the worst-case PCP concentration of 0.024 µg/g wet weight in Warm Springs Ponds fish fillet tissue yields an intake of 41,666g or 91 lbs of tissue per day to reach the limit of 1 mg PCP per day. The Ten-Day and Lifetime Health Advisories are 0.3 of the One-Day Health Advisory, indicating a 10kg (22 lb) child would have to consume 27 lbs per day of the worst-case tissue to exceed the No Observed Adverse Effect Level (NOAEL).

Attachment Table II-6 presents data for PCP concentrations in fish tissues found in the literature. Warm Springs Ponds fish fillet samples on a whole-tissue basis were much lower than either the fish fed an experimental diet of PCP or fish tested from Lake

Ontario (Niimi and Cho 1983). The concentration factors in Attachment Table II-6 show that PCP is concentrated by fish, and that the longer the organism is exposed, the greater the concentration factor. These data were insufficient for evaluating Warm Springs Ponds fish PCP concentrations. PCP concentrations were evaluated using Student's t-test and correlation tests.

As seen in Table 3-2, PCP shows a higher concentration in the reproductive tissues than in the fillet. However, this difference was not shown to be significant ($p.<.05$) for the means of PCP in the whole tissue or on a lipid basis.

Comparing PCP concentration means to PCB concentration means (Section 3.2.3) reveals that for fillets, PCP was significantly lower in concentration than PCBs ($p<.05$), and this pattern was repeated for reproductive tissue ($p<.05$). PCP concentrations in fillets weakly and negatively correlated with PCP concentrations in reproductive tissue (coefficient of determination = 0.64), but PCP concentrations in fillets on a lipid basis were not correlated at all with PCP concentrations in reproductive tissue on a lipid basis (coefficient of determination = 0.018).

3.2.3 PCB

Polychlorinated biphenyls (PCB) are synthetic chlorinated hydrocarbons. They are identified by numbers which describe the percentage of chlorine in the compound. Major PCBs manufactured are

Aroclor® 1221, 2132, 1242, 1248, 1254, 1260, 1262, and 1268; the last two digits in the number signify the percentage of chlorine. PCBs are poorly soluble in water, are soluble and concentrate in animal fats, and increase in food chains (Heath, et. al. 1972 in Schladweiler and Weigand 1983). PCBs have been listed under RCRA as a hazardous waste, and they were identified for analysis in SBC RI fish by the request of MDHES, because PCBs are potential contaminants within the SBC drainage area.

Table 3-3 summarizes the data found in Attachment Table I-6 and compares the PCB concentrations found in the tissue of Warm Springs Ponds fish to USDA standards for food. The comparison with the FDA standards are made on a wet-weight basis, as this is how the standards are given (21 CFR 109.3(b)). Attachment Table I-6 shows that the values for PCB in all of the fish fillets collected are lower than the FDA standard. The four reproductive tissue samples with sufficient tissue for extraction (T055-T was a very small sample) also showed PCB wet weight concentrations less than the food standards.

Attachment Table II-7 presents some PCB concentrations in fish tissue from the literature. Even though Lake McIlwaine data (Greichus, et al. 1978) are for the whole carcass, values are comparable (within ten times) to the fillet PCB concentrations reported for Warm Springs Ponds fish. The lake in Rhodesia is a reservoir constructed in 1952 below the city of Salisbury. In 1974, the year of sampling, the population of Salisbury was estimated at

TABLE 3-3
MEANS, STANDARD ERRORS AND RANGES OF PCB IN WARM SPRINGS PONDS FISH FILLETS AND REPRODUCTIVE TISSUES COMPARED TO PCB ACTION LEVELS IN FOOD (USDA NO DATE)

	Mean[a]	Standard Error[a]	Range[a]	FDA Tolerance level[a,b]
PCB in fillet, n=5, wet weight	0.338	0.0292	0.23-0.39	2.0[c]
PCB in fillet-Lipid Basis[d], n=5	11.4	1.84	4.43-14.9	
PCB in reproductive tissue[b], n=4, wet weight	0.378	0.127	0.179-0.717	2.0[c]
PCB in reproductive tissue-lipid basis[b,d], n=4	14.3	0.801	13.2-16.7	

(a) All values in ppm of PCB 1260.

(b) Reproductive tissue includes female eggs and male testes.

(c) FDA temporary tolerance for residues of PCB in Fish (29 CFR 109.30(b)). Calculated on a wet weight basis.

(d) ppm PCB on lipid basis calculated as $\frac{\text{mg PCB in Tissue}}{\text{kg lipid in Tissue}}$.

500,000. Greichus, et al. (1978) found that PCB concentrations in Lake McIlwaine fish below Salisbury were higher than PCB concentrations in fish found in another Rhodesian lake that was below a less populated area, indicating Lake McIlwaine was polluted with PCBs. The other data presented in Attachment Table III-7 indicate that PCBs occur at fairly high levels in watersheds that are populated. The Warm Springs Ponds fish PCB concentrations show similar concentrations to those found in aquatic systems downstream of urban areas. The actual sources and transport mechanisms for PCB in the Silver Bow Creek/Upper Clark Fork River system are unknown.

Distribution of PCBs in Warm Springs Ponds fish tissues and comparisons with PCP tissue concentration were evaluated using Student's t-test and correlation tests. As noted earlier in Section 3.2.1, mean PCB concentrations in Warm Springs Ponds fish fillets and reproductive tissue were significantly ($p < .05$) higher than the corresponding means for PCP concentrations. Paralleling PCP concentrations, mean PCB concentrations in reproductive tissue on a lipid basis were higher than mean PCB concentrations in muscle tissue on a lipid basis, but were not significantly higher ($p > .05$). PCB concentrations in fillets were not correlated with PCB concentrations in reproductive tissue on a tissue basis (coefficient of determination = 0.26).

However, on a lipid basis, reproductive tissue PCB concentrations appeared to be weakly and negatively correlated with fillet PCB concentrations (coefficient of determination = 0.84).

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4.0 CONCLUSIONS

4.1 METALS

Warm Springs Ponds fish muscle and liver tissues were analyzed for arsenic, cadmium, copper, and zinc concentrations. The data then were examined for concentrations greater than those naturally occurring, bioconcentration in and differential concentration between the two tissues, and concentrations above established standards.

Arsenic was not significant in any of the four evaluations. The fish did appear to bioconcentrate cadmium in their liver tissue, although not at levels above natural occurrence.

Zinc and copper both appear to be bioconcentrated by the fish, differentially between the muscle and liver (higher in the liver). Liver concentrations are greater than natural; however, only copper is above the standards. Zinc concentrations are greater in the muscle tissue.

4.1.1 Arsenic

Study results indicate that arsenic concentrations in Warm Springs Ponds fish were not elevated above naturally occurring concentrations, and these fish did not appear to have higher concentrations of arsenic than fish in the upper Clark Fork River. Comparing this study's tissue concentration data to RI water quality data was

inconclusive regarding bioconcentration of arsenic by Warm Springs Ponds fish. Arsenic did not appear to be differentially distributed between fillet and liver tissues, appeared to be in the same concentration ranges as cadmium in fillet and liver tissue, and appeared to be less concentrated than either copper or zinc in both fillet and liver tissues.

Data indicated that arsenic in Warm Springs Ponds fish fillets and livers did not occur at concentrations greater than the USDA's lowest standard of 0.50 µg/g.

4.1.2 Cadmium

Cadmium does not appear to be concentrating at higher than naturally occurring levels in Warm Springs Ponds fish muscle fillets or livers, and cadmium concentrations in Warm Springs Ponds fish fillets do not appear to be higher than cadmium concentrations in the muscle of fish living in the upper Clark Fork River below the ponds. Concentrations in Warm Springs Ponds fish were higher than ambient concentrations of cadmium, indicating some bioconcentration is occurring. Cadmium concentrations were in the same range as arsenic, but were much less than copper or zinc. Cadmium appears to be concentrating differentially in the tissues tested, occurring at higher concentrations in the liver tissue.

A person would have to eat 6.33 lbs/week of the worst-case fish fillets to reach the FAO/WHO standard of 500 µg/g cadmium per week. A person would have to eat 0.44 lbs/week of the worst-case liver tissue to consume the FAO/WHO standard amount.

4.1.3 Copper

Copper does not appear to be elevated above naturally occurring concentrations in Warm Springs Ponds fish fillets, but does appear to be elevated above naturally occurring concentrations in Warm Springs Ponds fish livers. Copper concentrations in Warm Springs Ponds fish fillets appear to be in the same range as muscle from fish living in the Clark Fork River below the ponds. Copper concentrations in Warm Springs Ponds fish fillet and liver tissues were greater than ambient water concentrations, indicating bioconcentration is occurring. Copper concentrations were higher in livers than muscle fillets in the tissues tested. Copper was found at greater concentrations than arsenic or cadmium in both livers and fillets and was higher than zinc in liver tissue.

Warm Springs Ponds fish showed fillet concentrations of copper less than the USDA standard for food of 100 µg/g, but showed liver concentrations of copper greater than the 100 µg/g standard.

4.1.4 Zinc

Fish in the Warm Springs Ponds do not appear to have greater than naturally occurring concentrations of zinc in their fillets. Zinc concentrations in Warm Springs Ponds fish fillets and upper Clark Fork River fish muscle appear to be similar. Zinc appears to be bioconcentrating in both fillet and liver tissue, with both having greater concentrations than is found in the ambient water. Zinc appeared to be differentially distributed, occurring at higher concentrations in tested livers than tested fillets. Zinc was found at higher concentrations than arsenic or cadmium in both fillet and liver tissues. Zinc was higher in concentration than copper in tested fillets, but was lower than copper in tested livers.

All tissues tested for zinc showed concentrations less than the Canadian Food Directorate standard of 100 µg/g.

4.2 ORGANICS

4.2.1 PCP

PCP was detected in all 10 tissues tested. Fillet concentrations ranged from 0.008-0.024 µg/g wet weight and ranged from 0.301-0.728 µg/g lipid based. Reproductive tissue concentrations ranged from 0.008-0.054 µg/g wet weight and ranged from 1.28-6.58 µg/g lipid based. A 10 kg (22 lb) child would have to consume 91 lbs/day or

27 lbs/day of the worst case fillet concentration to exceed the USEPA One-Day or Ten-Day and Lifetime Health Advisory No Observed Adverse Affect Levels for PCP. Literature data comparisons were inconclusive regarding Warm Springs Ponds fish PCP concentrations. PCP did not appear to be differentially distributed between the muscle fillet and reproductive tissues. PCP concentrations appeared to be less than PCB concentrations in both fillet and reproductive tissues.

4.2.2 PCB

All of five tested fish fillets showed concentrations less than the FDA food standard of 2.0 µg/g. All of five tested reproductive tissues showed concentrations of PCB less than the standard. Literature data indicated PCB contamination of fish is a widespread problem, but since Warm Springs Ponds fish are only exposed to Silver Bow Creek water and local sediments, the source for this PCB contamination must be local. PCB concentrations appeared to be higher than PCP concentrations in the tissues tested. PCB did not appear to be differentially distributed in the tissues tested.

4.3 RECOMMENDATIONS

No further RI/FS studies are recommended for metals or organis in fish tissue.

REFERENCES

Benoit, D.A., E.N. Leonard, G.M. Christensen, and J.T. Fiandt. 1976. Toxic Effects of Cadmium on Three Generations of Brook Trout (Salvelinus fontinalis). Transactions of the American Fisheries Society. 105(4):550-560.

Campbell, B. 1986. Personal Communication. Food and Drug Administration, Wash. D.C.

Colifano, R.J., J.M. O'Connor, and L.S. Peters. 1980. Uptake, Retention,aand Elimination of PCB (Aroclor 1254) by Larval Striped Bass (Morone saxatilis). Bulletin of Environmental Contamination and Toxicology. 24(3):467-472.

Dabrowski, K.R. 1976. The Effect of Arsenic on Embrional Development of Rainbow Trout (Salmo gairdneri Rich.). Water Resources. 20:793-796.

Defoe, D.L., G.D. Veith, and R.W. Carlson. 1978. Effects of Aroclor 1248 and 1260 on the Fathead Minnow (Pimephales promelas). Journal of the Canadian Fisheries Research Board. 35(7):997-1002.

Dent. R.L. 1977. Memorandum to George McArthur, Director of Environmental Affairs, M.M.D., Anaconda Minerals Company, Butte, Montana. Cited in Neher and Weisel, 1977.

Dent, R.L. 1975. Heavy Metals Concentrations in Brown Trout-Upper Clark Fork River Basin. Inhouse Report, Anaconda Minerals Company, Butte, Montana.

Eaton, J.G. 1974. Chronic Cadmium Toxicity to the Bluegill (Lepomis macrochinus Ratinesque). Transactions of the American Fisheries Society. 103(4):729-735.

EG&G. 1979. The Effects of Continuous Exposure to a Treated Mining/Smelting Effluent on Selected Aquatic Organisms. EG&G Bionomics Aquatic Toxicology Laboratory, Wareham, Massachusetts. For Smelter Environmental Research Association, Farmington, Michigan.

EG&G. 1978. The Effects of a Treated Copper Mining, Milling, and Smelting Effluent on Rainbow Trout (Salmo gairdneri) and the Water Flea (Daphnia magna) During Partial Chronic Exposure. EG&G Bionomics Aquatic Toxicology Laboratory, Wareham, Massachusetts. For Smelter Environmental Research Association, Farmington, Michigan.

Ellis, M.M., B.A. Westfall, and M.D. Ellis. 1941. Arsenic in Freshwater Fish. Industrial and Engineering Chemistry. 33(10):1331-1332.

FAO/WHO Expert Committee on Food Additives, 1972. WHO Technical Report Series, 16th Report, No. 505.

Farmer, G.J., et al. 1979. Effects of Zinc on Juvenile Atlantic Salmon (Salmo selar): Acute Toxicity, Food Intake, Growth, and Bioaccumulation. Environmental Pollution. 19:103.

Fox, M.E. and S.F. Joshi. The Fate of Pentachlorophenol in the Bay of Quinte, Lake Ontario. Journal of Great Lakes Research. 10(2):190-196.

Gilderhus, P.A. 1966. Some Effects of Sublethal Concentrations of Sodium Arsenite on Bluegills and the Aquatic Environment. Transactions of the American Fisheries Society. 95(3):289-296.

Goettl, J.P., Jr., J.R. Finley, and P.H. Davies. 1974. Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-9, Colorado Division of Wildlife, Fort Collins, Colorado. 96 pp.

Goettl, J.P., Jr., J.R. Finley, and P.H. Davies. 1972. Study of the Effects of Metallic Ions on Fish and Aquatic Organisms, Baseline Levels of Zinc and Copper in Rainbow Trout. In Water Pollution Studies. Job Progress Report, Federal Aid Project F-33-R-7. Colorado Division of Wildlife, Fort Collins, Colorado. pp. 42-45.

Greichus, Y.A., A. Greichus, H.A. Draayer, and B. Marshall. 1978. Insecticides, Polychlorinated Biphenyls and Metals in African Lake Ecosystems. II. Lake McIlwaine, Rhodesia. Bulletin of Environmental Contamination and Toxicology. 007-4861/78-0019-0444.

Hadley, W. 1986. Personal Communication. Fisheries Biologist, Montana Department of Fish, Wildlife, and Parks, Deerlodge, Montana.

Hadley, W. 1984. Personal Communication. Fisheries Biologist, Montana Department of Fish, Wildlife, and Parks, Deer Lodge, Montana.

Haile, C.L., G.A. Veith, G.F. Lee, and W.C. Boyle. 1975. Chlorinated Hydrocarbons in the Lake Ontario Ecosystem. U.S. EPA National Environmental Research Center, Corvallis, Oregon. EPA/660/3-75-022.

Havre, G.N., B. Underdal, and C. Christiansen. 1973. Cadmium Concentrations in Some Fish Species from a Coastal Area in Southern Norway. Oikos. 24:155-157.

Heath, R.G., J.W. Spann, J.F. Kreitzer, and C. Vance. 1972. Effects of Polychlorinated Biphenyls on Birds. Proceedings of the International Ornithologist Congress. 15:475-485.

Hedtke, S.F. and J.W. Arthur. 1985. Evaluation of a Site-Specific Criterion Using Outdoor Experimental Streams. Monticello Ecological Research Station, U.S. EPA Environmental Research Laboratory, Duluth, Minnesota. EPA/600/D-85/041.

Holton, G. 1983. Personal Communication with Jay Cornish of MultiTech. Fisheries Biologist, Montana Department of Fish, Wildlife, and Parks, Helena, Montana.

Huckins, J.N. and J.D. Petty. 1983. Dynamics of Purified and Industrial Pentachlorophenol in Fathead Minnows. Archives of Environmental Contamination and Toxicology. 12(6):667-672.

Kent, J.C. and D.W. Johnson. 1979. Mercury, Arsenic, and Cadmium in Fish, Water, and Sediment of American Falls Reservoir, Idaho, 1974. Pesticides Monitoring Journal. 13(1):35-40.

Kneip, T.J. and R.E. Hazen. 1979. Deposit and Mobility of Cadmium in a Marsh-Cove Ecosystem and the Relation to Cadmium Concentrations in Biota. Environmental Health Perspectives. 28:67-73.

Konizeski, D. 1978. The Montana Fishing Guide, Second Edition. Volume I: Montana Waters West of the Continental Divide. Mountain Press Publishing Company, Missoula, Montana.

Kumada, H., S. Kimura, M. Yokote, and Y. Matida. 1973. Acute and Chronic Toxicity, Uptake, and Retention of Cadmium in Freshwater Organisms. Bulletin of the Freshwater Fisheries Research Laboratory (Tokyo). 28:157-165.

Lieb, A.J., D.D. Bills, and R.O. Sinnhuber. 1974. Accumulation of Dietary Polychlorinated Biphenyls (Aroclor 1254) by Rainbow Trout (Salmo gairdenri). Agricultural and Food Chemistry. 22(4):638-642.

Lisk, D.J., P.C. Wszolek, T. Wachs, and W.D. Youngs. Persistence of Polychlorinated Biphenyls and 1, 1-Dichloro-2, 2-bis-(p-chlorophenyl) Ethelene (p, p-DDE) With Age in Lake Trout After 8 Years. Environmental Science and Technology. 13(10):1269-1271.

Lovett, R.J., W.H. Gutenmann, I.S. Pakkala, W.D. Youngs, D.J. Lisk, G.E. Burdick, and E.J. Harris. 1972. A survey of the Total Cadmium Content of 406 Fish From 49 New York State Fresh Waters. Journal of Fisheries Research Board of Canada. 29(9):1283-1290.

Lowe, T.P., T.W. May, W.G. Brumbaugh, and D.A. Kane. 1985. National Contaminant Biomonitoring Program: Concentrations of Seven Elements in Fresh Water Fish, 1978-1981. Archives of Environmental Contamination and Toxicology. 14:363-388.

Lucas, J.F., Jr., D.N. Edyington, and P.J. Colby. 1970. Concentrations of Trace Elements in Great Lake Fishes. Journal of Fisheries Research Board of Canada. 27(4):677-684.

Mathias, B.J. and T.F. Cummings. 1973. Selected Metals in Sediments, Water, and Biota in the Illinois River. Journal of the Water Pollution Control Federation. 45(7):1573-1583.

McKim, J.M. and D.A. Benoit. 1974. Duration of Toxicity Tests for Establishing "No Effect" Concentrations for Copper with Brook Trout (Salvelinus fontinalis). Journal of the Fisheries Research Board of Canada. 31(4):449-452.

Montana Department of Fish, Wildlife, and Parks (MDFWP). 1980. Stream Evaluation Map - State of Montana. MDFWP, Helena, Montana.

MultiTech and Stiller and Associates. 1984a. Silver Bow Creek Remedial Investigation Work Plan. For the Montana Department of Health and Environmental Sciences, Helena, Montana.

MultiTech and Stiller and Associates. 1984b. Silver Bow Creek Remedial Investigation Quality Assurance/Quality Control Program. For the Montana Department of Health and Environmental Sciences, Helena, Montana.

Munther, G. 1983. Personal Communication with Jay Cornish of MultiTech. Fisheries Biologist, Lolo National Forest, Montana.

National Marine Fisheries Service. 1975. First Report on Microconstituent Resource Survey. National Marine Fisheries Service, Southeastern Utilization Research Center, College Park, Maryland.

Neher, M.A. and G.F. Weisel. 1977. Heavy Metal Accumulation and Its Effect on the Biota of an Industrial Settling Pond. Montana University Joint Water Resources Research Center, Bozeman, Montana. MNJWRRL Report No. 90.

Niimi, A.J., and C.Y. Cho. 1983. Laboratory and Field Analysis of Pentachlorophenol (PCP) Accumulation by Salmonids. Water Research. 17(12):1791-1795.

Pakkala, I.S., M.N. White, G.E. Burdick, E.J. Harvis, and K.J. Lisk. 1972. A Survey of the Lead Content of the Fish From 49 New York State Waters. Pesticide Monitoring Journal. 5(4):348-355.

Phillips, G. 1983. Letter to Jim Dunn of the USEPA Helena Office. Pollution Control Biologist, Montana Department of Fish, Wildlife and Parks, Helena, Montana.

Phillips, G.R. 1982. Metals Residues in Brown Trout (Salmo trutta) From the Clark Fork and Little Blackfoot Rivers-1978. Montana Department of Fish, Wildlife, and Parks, Helena, Montana.

Phillips, G.R. and R.L. Russo. Metal Bioaccumulation in Fishes and Aquatic Invertebrates: A Literature Review. Environmental Research Laboratory, Office of Research and Development, USEPA, Duluth, Minnesota. EPA-600/3-78-103.

Pierce, R.H. 1978. Fate and Impact of Pentachlorophenol in a Freshwater Ecosystem. USEPA Environmental Research Laboratory, Athens, Georgia. EPA/600/3-78/063.

Renfro, W.C., S.W. Fowler, M. Heyrand and J. LaRosa. 1975. Relative Importance of Food and Water in Long-Term Zinc^{65} Accumulation by Marine Biota. Journal of Fisheries Resources Board of Canada. 32(8): 1339-1345.

Sandhu, S.S. 1977. Study on the Post-Mortem Identification of Pollutants in the Fish Killed by Water Pollution: Detection of Arsenic. Bulletin of Environmental Contaminants and Toxicology. 17(3):373-378.

Sangalang, G.B., and H.C. Freeman. 1979. Tissue Uptake of Cadmium in Brook Trout During Chronic Sublethal Exposure. Archives of Environmental and Toxicology. 8:77.

Schladweiler, P. and J.P. Weigand. 1983. Relationships of Endrin and Other Chlorinated Hydrocarbon Compounds to Wildlife in Montana, 1981-1982. Montana Department of Fish, Wildlife, and Parks, Helena, Montana.

Schroeder, H.A. 1974. The Poisons Around Us. Indiana University Press, Bloomington, Indiana. 144pp.

Snarski, V.M. and F.A. Puglisi. 1976. Effects of Aroclor 1254 on Brook Trout (Salvelinus fontinalis). USEPA Environmental Research Laboratory, Duluth, Minnesota. EPA/600/3-76/112.

Spaulding, Dr. John. 1986. Personal Communication. Director, Residue Evaluation and Surveillance Division, Food Safety and Quality Service, U.S. Department of Agriculture, Washington, D.C.

Spehar, R.L. et al. 1980. Comparative Toxicity of Arsenic Compounds and Their Accumulation in Invertebrates and Fish. Archives of Environmental Contamination and Toxicology. 9:55.

Spehar, R.L., et al. 1978. Chronic toxicity of Cadmium and Zinc Mixtures on Frogfish, Jordanella floridae. Transactions of the American Fisheries Society. 107:354.

Ullman, W.W., R.W. Schaefer, and W.W. Sanderson. 1961. Arsenic Accumulation by Fish in Lakes Treated with Sodium Arsenite. Journal of the Water Pollution Control Federation. 33(4):416-418.

U.S. Department of Agriculture (USDA). No Date. MPI Directive 9/7.1, Revision 2, Exhibit F. Received from Glenn Phillips, Montana Department of Fish, Wildlife and Parks, Helena, Montana.

U.S. Environmental Protection Agency (USEPA) 1985. Draft Health Advisory for Pentachlorophenol. Office of Drinking Water, USEPA, Washington, D.C.

USEPA. 1984. Characterization of Hazardous Waste Sites--A Methods Manual. Volume III: Available Analytical Methods. USEPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. EPA-600/4-84-038.

USEPA. 1983. Methods for the Chemical Analysis of Water and Wastes. USEPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-79-020.

USEPA. 1982. Methods for Organic Chemical Analysis of Municipal and Industrial Waste Water. USEPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. EPA-600/4-82-057.

USEPA. 1981. Biological Monitoring of Trace Elements. Environmental Monitoring Systyems Laboratory, Las Vegas, Nevada. EPA-600/53-80-090.

USEPA. 1980a. Ambient Water Quality Criteria for Cadmium. USEPA, Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C.

USEPA. 1980b. Ambient Water Quality Criteria for Copper. USEPA Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C.

USEPA. 1978. In-depth Studies on Health and Environmental Impacts of Selected Water Pollutants. Contract No. 68-01-4646. USEPA, Washington, D.C.

Van Meter, W.P. 1974. Heavy Metals Concentrations in Fish Tissues of the Upper Clark Fork River. Montana University Joint Water Resources Research Center. Bozeman, Montana.

Veith, G.D., D. Kuehl, E.N. Leonard, K. Welch, and G. Pratt. 1981. Polychlorinated Biphenyls and Other Organic Chemical Residues in Fish From Major United States Watersheds Near the Great Lakes, 1978. Pesticides Monitoring Journal. 15(1):1-8.

Veith, G.D. 1975. Baseline Concentrations of Polychlorinated Biphenyls and DDT in Lake Michigan Fish, 1971.

Walsh, L. 1983. Personal Communication with Jay Cornish of Multi-Tech. Fisheries Biologist, Helena National Forest, Helena, Montana.

Wisconsin Department of Natural Resources. 1974. Concentration of Metals in Fish. Technical Bulletin No. 74. Department of Natural Resources, Madison, Wisconsin. pp. 8-15.

SILVER BOW CREEK REMEDIAL INVESTIGATION
FISH TISSUE

DRAFT

ATTACHMENT I

METALS AND ORGANICS IN WARM SPRINGS PONDS FISH TISSUE
ANALYSIS DATA AND QA/QC DATA

MultiTech

TABLE I-1

ARSENIC IN WARM SPRINGS PONDS FISH TISSUE

Lab No.	Run 1 µg/g	Run 2 µg/g	DSA%
TO50M	0.080	<0.143	<128%
TO50L	<0.055	<0.160	<148%
TO51M	0.235	0.146	76%
TO51L	0.390	0.455	107%
TO52M	0.088	<0.143	<144%
TO52L	<0.055	--	--
TO53M	<0.055	<0.143	<144%
TO53L	<0.055	0.182	150%
TO57M	<0.055	<0.144	<144%
TO57L	<0.055	<0.144	<144%

QA/QC SUMMARY

Lab No.	Run 1	Run 2
Q961:Blank	<0.0072 mg/L	<0.011 mg/L
Q962:Blank	<0.0072 mg/L	NP(g)
Q963:Duplicate	DSA%(a) = 99	100
Q964:Duplicate	DSA%(a) = 74	NP
Q965:Standard	KSA%(b) = 5	101
Q966:Standard	KSA%(c) = 163	360
Q967:Standard	KSA%(d) = 143	40
Q968:Spike	SSR%(e) = 137	49
Q969:Duplicate	DSA%(f) = 102	NP

Analyst Replicates (DSA%)

Run 1	Run 2	Required Range
Q967-R 99	TO51L-R 106	5-115 or ± 1 MDL
TO51M-R 97	Q967-R 96	

Analyst Calibration Checks (KSA%)

Run 1	Run 2	Required Range
W5378 102	W5378 110	85-115 or ± 1 MDL
W5378 101	W5378 102	

TABLE I-1

ARSENIC IN WARM SPRINGS PONDS FISH TISSUE
(Continued)

Analyst Spikes (SSR%)				
Run 1		Run 2		Required Range
Q963-S	82	TO51M-S	94	75-125 or ± 1 MDL
TO37L-S	84	TO53L-S	101	

(a) Tissue Split
(b) EPA Metals in Fish
(c) NBS Metals in Bovine Liver
(d) EPA Metals in Water
(e) Predigestion Spike
(f) Digest Split
(g) NP = Not Performed

Note

$$DSA\% = \frac{M_2}{(M_1 + M_2)/2} * 100$$

$$KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$$

$$SSR\% = \frac{(\text{Spiked Sample}) - (\text{Sample})\ (\text{Dil. Factor})}{(\text{Spike})\ (\text{Dil. Factor})} * 100$$

TABLE I-2

CADMIUM IN WARM SPRINGS PONDS FISH TISSUE

Lab No.	Run 1 µg/g	Run 2 µg/g	DSA%
TO50M	0.019	0.174	180%
TO50L	1.05	0.50	64%
TO51M	0.028	0.082	<149%
TO51L	2.32	1.39	75%
TO52M	0.089	0.082	<96%
TO52L	2.51	1.54	76%
TO53M	0.020	<0.083	<161%
TO53L	1.36	0.427	48%
TO57M	0.010	<0.083	<178%
TO57L	0.688	<0.083	<21%

QA/QC SUMMARY

Lab No.	Run 1	Run 2
Q961:Blank	<0.001	0.010
Q962:Blank	<0.001	--
Q963:Duplicate	DSA%(a) = 175	100
Q964:Duplicate	DSA%(a) = 91	--
Q965:Standard	KSA%(b) = 58	103
Q966:Standard	KSA%(c) = 268	70
Q967:Standard	KSA%(d) = 270	60
Q968:Spike	SSR%(e) = 261	60
Q969:Duplicate	DSA%(f) = 100	--

Analyst Replicates (DSA%)

Run 1		Run 2		Required Range
TO52M-R	107	TO50L-R	107	85-115 or ± 1 MDL
Q965-R	99	TO50L-R	94	
TO52L-R	101	Q967-R	98	

Analyst Calibration Checks (KSA%)

Run 1		Run 2		Required Range
W5378	90	WP284 #2	108	85-115 or ± 1 MDL
W5378	94	WP284 #2	100	
0.1 ppm	110			

TABLE I-2

CADMIM IN WARM SPRINGS PONDS FISH TISSUE
(Continued)

Analyst Spikes (SSR%)				
Run 1		Run 2	Required Range	
TO53M-S	82	TO51L-S	75-125 or ± 1 MDL	
Q963-S	89	Q966-S		
TO52L-S	123			

(a) Tissue Split
(b) EPA Metals in Fish
(c) NBS Metals in Bovine Liver
(d) EPA Metals in Water
(e) Predigestion Spike
(f) Digest Split

Note

$$DSA\% = \frac{M}{(M_1 + M_2)/2} * 100$$

$$KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$$

$$SSR\% = \frac{(\text{Spiked Sample}) - (\text{Sample})(\text{Dil. Factor})}{(\text{Spike})(\text{Dil. Factor})} * 100$$

TABLE I-3

COPPER IN WARM SPRINGS PONDS FISH TISSUE

Lab. No.	µg/g
TO50M	0.838
TO50L	194.
TO51M	0.675
TO51L	104.
TO52M	0.488
TO52L	200.
TO53M	<0.325
TO53L	202.
TO57M	0.463
TO57L	738.

QA/QC SUMMARY

Q961:Blank	<0.037 mg/L
Q962:Blank	<0.037 mg/L
Q963:Duplicate	DSA%(a) = 146
Q964:Duplicate	DSA%(a) = 92
Q965:Standard	KSA%(b) = 105
Q966:Standard	KSA%(c) = 116
Q967:Standard	KSA%(d) = 82
Q968:Spike	SSR%(e) = 100
Q969:Duplicate	DSA%(f) = 113

Analyst Replicates

Lab. No.	DSA%/RSA%	Required Range
TO51L-R	98	85-115 or ± 1 MDL
Q965-R	90	

Analyst Calibration Checks

Lab. No.	KSA%	Required Range
WP284 #2	94	85-115 or ± 1 MDL
WP284 #2	96	

TABLE I-3

COPPER IN WARM SPRINGS PONDS FISH TISSUE
(Continued)

Analyst Spikes		
Lab. No.	SSR%	Required Range
TO53L-S	99	75-125 or ± 1 MDL
0963-S	89	

(a) Tissue Split
(b) EPA Metals in Fish
(c) NBS Metals in Bovine Liver
(d) EPA Metals in Water
(e) Predigestion Spike
(f) Digest Split

Note

$$DSA\% = \frac{M_2}{(M_1 + M_2)/2} * 100$$

$$KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$$

$$SSR\% = \frac{(\text{Spiked Sample}) - (\text{Sample})\ (\text{Dil. Factor})}{(\text{Spike})\ (\text{Dil. Factor})} * 100$$

TABLE I-4

ZINC IN WARM SPRINGS PONDS FISH TISSUE

Lab. No.	µg/g
TO50M	3.74
TO50L	32.2
TO51M	6.18
TO51L	62.2
TO52M	6.12
TO52L	51.9
TO53M	5.31
TO53L	45.9
TO57M	3.96
TO57L	39.8

QA/QC SUMMARY

Q961:Blank	<0.031 mg/L
Q962:Blank	<0.031 mg/L
Q963:Duplicate	DSA%(a) = 103
Q964:Duplicate	DSA%(a) = 100
Q965:Standard	KSA%(b) = 95
Q966:Standard	KSA%(c) = 109
Q967:Standard	KSA%(d) = 91
Q968:Spike	SSR%(e) = 112
Q969:Duplicate	DSA%(f) = 104

Analyst Replicates

Lab. No.	DSA%/RSA%	Required Range
TO51L-R	98	85-115 or ± 1 MDL
Q965-R	91	

Analyst Calibration Checks

Lab. No.	KSA%	Required Range
WP284 #2	96	85-115 or ± 1 MDL
WP284 #2	101	

TABLE I-4

ZINC IN WARM SPRINGS PONDS FISH TISSUE
(Continued)

Analyst Spikes

Lab. No.	SSR%	Required Range
TO53L-S	106	75-125 or ± 1 MDL
0963-S	80	

(a) Tissue Split
(b) EPA Metals in Fish
(c) NBS Metals in Bovine Liver
(d) EPA Metals in Water
(e) Predigestion Spike
(f) Digest Split

Note

$$DSA\% = \frac{M_2}{(M_1 + M_2)/2} * 100$$

$$KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$$

$$SSR\% = \frac{(\text{Spiked Sample}) - (\text{Sample})\ (\text{Dil. Factor})}{(\text{Spike})\ (\text{Dil. Factor})} * 100$$

TABLE I-5
PCP CONCENTRATIONS OF WARM SPRINGS PONDS FISH

Species	Sex	Lab No.	Fillet (ppm)	Fillet[a] Lipid (ppm)	Reproductive[b] (ppm)	Reproductive Lipid[a,b] (ppm)
Salmo gairdneri	M	T049	0.012	0.408	0.020(T)	1.48(T)
Salmo gairdneri	F	T051	0.019	0.728	0.030(E)	2.79(E)
Salmo gairdneri	F	T054	0.008	0.301	0.054(E)	1.04(E)
Salmo gairdneri	M	T055	0.024	0.462	0.008(T)	6.58(T)
Salmo gairdneri	F	T058	0.012	0.577	0.042(E)	1.28(E)

QA Notes

Internal QA/QC sample data available in files of contract laboratory. Independent sample bank samples generated the following data:

Sample bank blank: Q970 <.005 ppm.

Sample bank duplicate: Q972
Whole Tissue DSA% = 114[c]

Sample bank standard: Q974
KSA% = 35%[d]

(a) ppm PCP on lipid basis calculated as $\frac{\text{mg PCP in Tissue}}{\text{kg lipid in Tissue.}}$

(b) T = Testes
E = Eggs

(c) $$DSA\% = \frac{M_2}{(M_1 + M_2)/2} * 100$$

(d) $$KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$$

TABLE I-6
PCB CONCENTRATIONS OF WARM SPRINGS PONDS FISH

Species	Sex	Lab No.	Fillet[a] (ppm)	Fillet[a,b] Lipid (ppm)	Reproductive[a,c] (ppm)	Reproductive Lipid[a,c] (ppm)
Salmo gairdneri	M	T049	0.330	11.2	0.183(T)	13.6(T)
Salmo gairdneri	F	T051	0.390	14.9	0.179(E)	16.7(E)
Salmo gairdneri	F	T054	0.355	13.3	0.717(E)	13.8(E)
Salmo gairdneri	M	T055	0.230	4.43	<0.05(T)	<41.0(T)
Salmo gairdneri	F	T058	0.386	13.2	0.433(E)	13.2(E)

QA Notes

Internal QA/QC sample data available in files of contract laboratory. Independent sample bank samples generated the following data:

Sample bank blank: Q971 <.0004 mg/sample

Sample bank duplicate: Q973

Whole Tissue DSA% = 54%[d]

Lipid Based DSA% = 98%[d]

Sample bank standard: Q975
KSA% = 69%[e]

(a) Values are for PCB 1260.

(b) ppm PCP on lipid basis calculated as $\frac{\text{mg PCP in Tissue}}{\text{kg lipid in Tissue.}}$

(c) T = Testes
E = Eggs

(d) $DSA\% = \frac{M_2}{(M_1 + M_2)/2} * 100$

(e) $KSA\% = \frac{\text{Measured Value}}{\text{True Value}} * 100$

SILVER BOW CREEK REMEDIAL INVESTIGATION
FISH TISSUE

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ATTACHMENT II

CONCENTRATIONS OF ARSENIC, CADMIUM, COPPER, ZINC, PCP, AND PCB
IN FISH TISSUE-EXAMPLES FROM THE LITERATURE

MultiTech

TABLE II-1
ARSENIC IN FISH TISSUE-EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. µg/g ppm(a)
Gilderhus 1966(b)	Lab	Bluegill (Lepomis macrochirus) Adult and Immature	16 weeks	.3 - 9.0	.3 - 9.0
Dabrowski 1976(b)	Lab	Rainbow Trout (Salmo gairdneri) eggs.	40 days	.05	2.5 (max)
Ullman, et. al. 1961(b)	New York Lake	Calico bass (Pomoxis nigromaculatus)/ muscle fillet	Exposed to Sodium Arsenite used as herbicide		.10 - .47 No difference from before and after treatment.
Pakkala, et. al. 1972(b)	New York Lakes	Various muscle	Not Given	Not Given	.5 (max)
Sandhu 1977(b)	Not Given (Uncontaminated)	Various muscle	Not Given	2.5(max)	12.5(max)
Ellis, et. al. 1941(b)	S.E. US	Various whole fish	Life span	Not Given	.75
Wisconsin Department of Natural Resources 1974(b)	Natural	Various Edible Portion	Life Span	Not Given	<1.0
Kent and Johnson 1979	American Falls Reservoir (Snake River, Idaho)	Rainbow Trout (Salmo gardneri)/ Edible portion	Life Span	.0015-.033	Not detected.
Olsen and Schell	Puget Sound	Muscle/ English Sole Dover Sole	Life Span		22-41(c) <.05-51(c)
Greichus et. al. 1978	Lake McIlwaine, Rhodesia	Mixed/Whole carcass	Life Span	n=3, .003(x)(d)	n=3, .35 (x)(d)

(a) Wet weight.
(b) From Phillips and Russo 1978.
(c) Dry weight. W/D = 5.1.
(d) Dry weight divided by 4.

TABLE II-2
CADMIUM IN FISH TISSUE-EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. µg/g ppm[a]
Havre, et. al. 1973[b]	Marine-off Norway Coast	Various/ muscle?	Life span	Not Given	.002 - .033
Lovett et. al. 1972[b]	New York State Lakes	Various/ muscle?	Life span	Not Given	.02 - .10
Benait, et. al. 1976[b]	Lab	Brook trout (Salvelinus fontinalis)/various	38 weeks	.0034 (lowest damaging concentration)	kidney>liver> gill>muscle
Eaton, 1974[b]	Lab	Bluegill	11 months	.031-2.14 No effect between .031 and .080	Not Applicable
Kumada, et. al. 1973[b]	Lab	Rainbow trout (Salmo gairdneri)/ various	40 weeks	Various	liver=kidney> gills>muscle
Wisconsin Department of Natural Resources 1973[b]	Natural	Various/Edible Portion	Life Span	Not Given	Not Detected
Kent and Johnson 1974	American Falls Reservoir (Snake River, Idaho)	Rainbow Trout (Salmo gairdneri)/ Edible Portion	Life Span	.001-.024	x=.51 SD=.04 Range .32-.80
Mathias and Cummings 1973[c]	Illinois River	Various/Edible Portion	Life Span	.0001-.002	.03
Schroeder 1974[c]	Hudson River	Various/Edible Portion	Life Span	.003-.006	.2-304
Schroeder 1974[c]	Alabama River	Various/Edible Portion	Life Span	.006-.090	.8(max)

TABLE II-2
CADMIUM IN FISH TISSUE-EXAMPLES FROM THE LITERATURE (Cont.)

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. µg/g ppm[a]
Lucas, et. al. 1970[c]	Great Lakes	Various/Edible	Life Span	Not Given	.06 - 1.4
Olsen and Schell 1977	Puget Sound	Muscle English Sole Dover Sole	Life Span		<.05[d] <.05[d]
Kneip and Hazen 1979	Foundry Cove, New York	Sunfish/Edible portion	Life Span	up to 10,000 mg/kg (dry) in sediment	.15
Kneip and Hazen 1979	Foundry Cove, New York	Sunfish/Liver	Life Span	up to 10,000 mg/kg (dry) in sediment	7.2
National Maine Fisheries Service 1975[e]	Atlantic	44 species/ Edible portion	Life Span	Not Given	<.025 one species exceeded .025
Greichus, et. al. 1978	Lake McIlwaine, Rhodesia	Mixed/whole carcass	Life Span	n=3, .001(x)	n=3, .03(x)[f]

(a) Wet Weight.
(b) From Phillips and Russo 1978.
(c) From Kent and Johnson 1979.
(d) Dry weight w/D - 5.1.
(e) From Kneip and Hazen 1979.
(f) Dry weight divided by 4.

TABLE II-3
COPPER IN FISH TISSUE-EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. µg/g ppm(a)
Goettl, et. al. 1972(b)	Lab (Research Hatchery)	Rainbow trout (Salmo gairdneri)			
		Bone	92 weeks	Not Given	7.3(c)
		eye	"	"	4.3(c)
		gill	"	"	4.9(c)
		intestine	"	"	9.6(c)
		kidney	"	"	12.9(c)
		muscle	"	"	1.7(c)
McKim and Benoit 1974(b)	Lab	Brook trout (Salvelinus fontinalis) gill, kidney, liver, muscle	Egg--Spawning	.0094(max)	Not Detected
Goett, et. al. 1974(b)	Lab	Rainbow trout (Salmo gairdneri) liver	107 weeks	.003	>.003
Olsen and Schell 1977	Puget Sound	Muscle	Life Span		
		English Sole			.25-2(d)
		Dover Sole			.20-.25(d)
Greichus et. al. 1978	Lake McIlwaine, Rhodesia	Mixed/whole carcass	Life Span	n=3,.010(x)	n=3, 5.4(x)(e)

(a) Wet weight.
(b) From Phillips and Russo 1978.
(c) Dry weight.
(d) Dry weight W/D = 5.1
(e) Dry weight divided by 4.

TABLE II-4
ZINC IN FISH TISSUE-EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. µg/g ppm(a)
Goettl, et. al. 1972(b)	Lab (Research Hatchery)	Rainbow trout (Salmo gairdneri)	92 weeks	Not Given	
		eye	"	"	4003(c)
		skin	"	"	90(c)
		gill	"	"	200(c)
		bone	"	"	195(c)
		stomach	"	"	1(c)
		liver	"	"	150(c)
		muscle	"	"	20(c)
		kidney	"	"	125(c)
		intenstine	"	"	190(c)
Slater 1961(b)	Lab	Various/Gill filaments	Not Given	Not Given	Brook trout (Salvelinus fontinalis)= cutthroat trout (Salmo clarkii)> Rainbow Trout (Salmo gairdneri)
Wisconsin Department of Natural Resources 1974(b)	Natural Waters	Various/Edible Portion	Ambient	Not Given	3.0 - 18.3
Olsen and Schell 1977	Puget Sound	Muscle/ English Sole	Life Span	Not Given	17-25(d)
		Dover Sole			14-17(d)
Greichus, et. al. 1978	Lake McIlwaine, Rhodesia	Mixed/whole carcass	Life Span	n=3, .012(x)	n=3, 12.0(x)(e)

(a) Wet weight
(b) From Phillips and Russo 1978.
(c) Dry weight.
(d) Dry weight W/D = 5.1
(e) Dry weight divided by 4.

TABLE II-5
BACKGROUND FISH TISSUE CONCENTRATIONS OF ARSENIC, CADMIUM, COPPER AND ZINC IN THE UNITED STATES

	1978-79				1980-81			
	GM	Min	Max	85 Percentile	GM	Min	Max	85 Percentile
As	.16	.04	2.08	.23	.14	.05	1.69	.22
Cd	.04	.01	.41	.09	.03	.01	.35	.06
Cu	.86	.29	38.75	1.14	.68	.25	24.10	.90
Zn	25.63	7.69	168.1	46.26	23.82	8.82	109.2	40.09

All data in µg/g wet weight. GM = geometric mean.

Source: Lowe, et. al. 1985.

TABLE II-6
PCP IN FISH TISSUE - EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Concentration (ppm)	Tissue Concentration (ppm)
Fox and Joshi 1984	Lake Ontario	Mixed/whole carcass	Life Span	Various	Concentration Factor = 10^4
Huckins and Petty 1983	Lab	Fathead minnows (Pimephales promelas)/various	31 days	.050	Concentration Factor: 174-284
Niimi and Cho 1983	Lab	Rainbow trout (Salmo gairdneri)/ various	110 days	Dietary of 10 µg/kg	2-20
Niimi and Cho 1983	Lake Ontario	Various/Various	Life Span	Not Given	1-10
Pierce 1978	Lab	Bluegill (Lepomis macrochirus)/ various	Various	Various	Bile>Liver>Gills> Muscle

TABLE II-7
PCB'S IN FISH TISSUE - EXAMPLES FROM THE LITERATURE

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. ppm[a]
Greichus et al. 1978.	Lake McIlwaine, Rhodesia	Dwarf bream/ Whole carcass	Life Span	<.001[b]	n=50: A1254, 1.8(x)[b] A1260, .51(x)[b]
"	"	Spot Tail/Whole Carcass	"	"	n=50: A1254, 1.7(x)[b] A1260, <.5(x)[b]
"	"	Greenheaded bream/ Whole carcass	"	"	n=50: A1254, .98(x)[b] A1260, <.5(x)[b]
"	"	Greenheaded bream/ Whole carcass	"	"	n=5: A1254, .92(x)[b] A1260, <.5(x)[b]
Defoe et al. 1978	Lab	Fathead minnow (Pimepholes promeles) Various	30 days	Various: LC-50 for A1248 4.7 lg/l LC-50 for A1260 = 3.3 lg/l	
Defoe et al. 1978	Lab	Fathead minnows (Pimepholes promeles) Various		Various	Concentration factor = 126 for A1248 in females. Concentration factor = 2727 for A1260 in females.
Califano et al. 1980	Lab	Striped bass (Morone saxitilis/ muscle	48 hours	Various	5.9
Lisk et al. 1979	Cayuga Lake, New York	Lake trout (Salvelinus namaycush)/flesh	Life Span	Not Given	13.0
Veith et al. 1981	Watershed of Great Lakes	Various/Composite	Life Span	Not Given	.13 - 14.6 65% had at least 2.0

TABLE II-7
PCB'S IN FISH TISSUE - EXAMPLES FROM THE LITERATURE
(Continued)

Citation	Location	Species/Tissue	Exposure	Water Conc. (ppm)	Tissue Conc. ppm(a)
Veith 1975	Lake Michigan	Thirteen species/ composite	Life Span	Not Given	Rainbow smelt = 2.7(x) Lake Trout = 15.0 (x) Trout and Salmon >12 inches >5.0 ppm
Snarksi and Puglisi 1976	Lab	Brook trout (Salvelinus fontinalis)/fillet	71 Weeks	.00094	2.0
Snarski and Puglisi 1976	Lab	Brook trout (Salvelinus fontinalis)/whole body	71 Weeks	.00094	9.0
Haile, et al. 1975	Lake Ontario	Various/Whole Fish	Life Span	.055(x)	5.15(x)
Lieb et al. 1974	Lab	Rainbow Trout (Salmo gairdneri)/ Whole Fish	32 Weeks	15.0 ppm in diet	10.2(x)

(a) Wet Weight

(b) Dry Weight

TABLE II-8
BIOCONCENTRATION FACTORS OF CADMIUM

Species	Tissue	Chemical	Bioconcentration Factor	Duration (days)	Reference
Rainbow trout (*Salmo gairdneri*)	Whole body	--	540	140	Kumada, *et al.* 1973
Rainbow trout (*Salmo gairdneri*)	Whole body	Cadmium Chloride	33 at 4 µg/L	10 wks	Kumada, *et al.* 1980 (Cited in USEPA 1980)
Brook trout (*Salvelinus fontinallis*)	Muscle	Cadmium Chloride	3	490	Benoit, *et al.* 1976
Brook trout (*Salvelinus fontinallis*)	Muscle	Cadmium Chloride	151	84	Benoit, *et al.* 1976
Brook trout (*Salvelinus fontinallis*)	Muscle	Cadmium Chloride	10	93	Sangalang and Freeman, 1979

SILVER BOW CREEK REMEDIAL INVESTIGATION
FISH TISSUE

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ATTACHMENT III

METALS IN THE FISH OF THE CLARK FORK RIVER - HISTORICAL DATA.
METALS AND ORGANICS IN WATER - RI DATA

MultiTech

TABLE III-1
METAL CONCENTRATIONS IN A BROWN TROUT (*Salmo trutta*) COLLECTED IN WARM SPRINGS POND NO. 3 IN 1976

Metal	Concentration (µg/g wet)
As	0.51
Cu	.825
Cd	<.05
Zn	5.43

Source: Dent 1977.

TABLE III-2
AVERAGE CONCENTRATIONS OF CADMIUM, COPPER, AND ZINC IN TROUT (*Salmo spp.*) MUSCLE AND LIVER FROM THE CLARK FORK DRAINAGE

Metal	Muscle µg/g	Liver µg/g
Cd	.19	.69
Cu	1.47	11.4
Zn	6.3	38

Source: Van Meter 1974.

TABLE III-3
AVERAGE CONCENTRATIONS OF CADMIUM AND COPPER IN TROUT (*Salmo* spp.) LIVER FROM THE UPPER CLARK FORK RIVER COMPARED TO AVERAGE CONCENTRATIONS OF CADMIUM AND COPPER FROM ROCK CREEK OF THE MIDDLE CLARK FORK DRAINAGE

Metal	UCFR(a) µg/g	RC(b) µg/g
Cd	1.1(3)	1.9(3)
Cu	14(3)	17(3)

(a) The Upper Clark Fork River sampling stations included three below the Warm Springs Ponds and one below the confluence with the Little Blackfoot River.

(b) The five Rock Creek stations were all on the main stem of Rock Creek.

(c) Numbers in parentheses are the number of samples used to calculate the average.

Source: Van Meter 1974.

TABLE III-4

MEANS, STANDARD DEVIATIONS AND RANGES OF LENGTH, WEIGHT, AND METAL, AND METAL CONCENTRATIONS IN BROWN TROUT FROM TWO SECTIONS OF THE CLARK FORK RIVER AND ONE ON THE LITTLE BLACKFOOT RIVER; SAMPLING CONDUCTED SEPTEMBER 18-19, 1978

Location	Age Class	No.	Length (mm)	Weight (gm)	Metal concentration (µg/g) Cu	Cd	As	Zn
Clark Fork-pH Shack[a]	I	17	234±23 (188-272)	136±50 (73-213)	0.10±0.27 (ND-0.83)	0.43±0.45 (ND-1.12)	0.16±0.08 (0.02-0.29)	4.45±1.85 (1.35-7.75)
Clark Fork-Williams-Tavenner[b]		12	241±15 (218-267)	154±18 (123-195)	0.25±0.76 (ND-2.41)	0.05±0.05 (ND-0.13)	0.10±0.05 (0.05-0.20)	4.81±1.10 (3.19-6.52)
Little Blackfoot		8	213±13 (198-239)	104±14 (91-136)	0.05±0.15 (ND-0.43)	0.21±0.23 (ND-0.56)	0.10±0.08 (0.01-0.26)	4.85± 0.68 (3.53-5.76)
Clark Fork-pH Shack	II	18	310±33 (246-371)	318±95 (181-599)	0.15±0.29 (ND-0.92)	0.56±0.49 (0.06-1.36)	0.12±0.08 (0.03-0.31)	4.15±2.04 (1.90-5.37)
Clark Fork-Williams-Tavenner		14	297±31 (249-343)	286±82 (163-440)	0.03±0.07 (ND-0.24)	0.11±0.12 (ND-0.45)	0.08±0.04 (0.02-0.17)	4.09±1.11 (2.60-6.60)
Little Blackfoot		15	285±23 (249-338)	240±68 (145-404)	0.02±0.04 (ND-0.06)	0.07±0.07 (ND-0.20)	0.15±0.13 (0.03-0.50)	3.55±1.29 (1.49-6.89)
Clark Fork-pH Shack	III	6	366±28 (335-414)	508±113 (377-694)	-- --	1.20±0.55 (0.22-1.41)	0.12±0.07 (0.03-0.24)	4.63±0.74 (3.79-5.58)
Clark Fork-Williams-Tavenner		15	361±25 (320-406)	531±118 (363-767)	0.12±0.15 (ND-0.43)	0.09±0.11 (ND-0.20)	0.05±0.04 (0.01-0.12)	3.83±1.20 (1.90-6.46)
Little Blackfoot		9	351±30 (310-399)	467±132 (331-690)	0.12±0.15 (ND-0.39)	0.21±0.41 (ND-1.10)	0.28±0.26 (0.05-0.83)	3.69±0.61 (2.88-4.89)
Clark Fork-pH Shack	IV	3	452±58 (412-518)	993±445 (735-1505)	-- --	0.83±0.64 (0.20-1.48)	0.01±0.02 (ND-0.03)	3.52±0.58 (3.12-4.18)
Clark Fork-Williams-Tavenner		6	432±38 (406-503)	984±667 (672-1716	0.25±0.22 (ND-0.53)	0.41±0.57 (ND-1.26)	0.13±0.16 (0.02-0.45)	3.92±1.04 (2.65-5.20)
Little Blackfoot		6	439±43 (394-498)	948±286 (721-1397)	0.28±0.37 (ND-0.97)	0.22±0.35 (0.02-0.93)	0.18±0.29 (0.02-0.76)	3.7610.39 (3.37-4.34)

(a) pH shack section on the upper Clark Fork River was just below the confluence of the outfall from the Warm Springs Ponds and Warm Springs Creek.

(b) Williams Tavenner section on the Upper Clark Fork River was below Deer Lodge.

Source: Phillips 1982.

TABLE III-5
CONCENTRATIONS OF ARSENIC, CADMIUM, COPPER, AND ZINC
IN THE DISCHARGE FROM THE WILDLIFE PONDS (PS-11A) DURING THE SBC RI

Date	As	Cd	Cu		Zn	
	Total[a]	Total[a]	Diss[a]	Total[a]	Diss[a]	Total[a]
12/05/84	.0096	<.0005	.010	.021	.015	.015
12/25/84	.0078	<.0008	<.031	<.031	.035	.042
1/30/85	.0062	<.0004	<.025	<.039	.102	.088
2/13/85	.012	<.0012	<.017	.032	.186	.202
2/13/85	.010	<.0012	<.026	.034	.163	.250
2/27/85	.012	<.0011	<.027	.072	.075	.101
3/13/85	.0081	<.0028	.076*	.065	.033	.044
3/27/85	.011	<.0015	.014	<.049	<.017	<.017
4/10/85	.0159	<.0011	<.019*	.043	<.014	.011
4/24/85	.014	<.0005	<.014*	<.013	.009	.011
5/08/85	.013	<.0003	.018	.022	<.017	.015
5/22/85	.013	<.00025	<.030	.038	<.011	.015
6/05/85	.011	<.00025	<.015	.0098	<.012	.021
6/19/85	.014	<.0010	<.021	.021	<.006	.023
7/24/85	.018	<.0002	<.023	.048	<.006	.019
8/29/85	.013	<.00025	<.021	<.005	<.017	.009

* Not Validated due to requested reruns being past holding time. Reruns were requested to lower the MDL.

(a) Values reported in mg/L.

TABLE III-6
CONCENTRATIONS OF ARSENIC, CADMIUM, COPPER, AND ZINC
IN THE WEST DECANT TOWER DISCHARGE DITCH

Date	As	Cd	Cu		Zn	
	Total(a)	Total(a)	Diss.(a)	Total(a)	Diss.(a)	Total(a)
12/05/84	0.0095	0.00070	0.019	0.044	0.148	0.206
12/28/84	0.0094	0.0013	<0.031	0.052	0.171	0.306
1/30/85	0.012	0.0018	<0.025	0.056	0.415	0.524
2/13/85	0.011	0.0012	0.027	0.063	0.388	0.449
2/27/85	0.014	0.0013	<0.027	0.065	0.308	0.379
3/13/85	0.0077	0.0014	<0.018*	0.106	0.403	0.341
3/27/85	0.016	<0.0015	0.065*	0.097	0.155	0.285
4/10/85	0.025	0.0017	0.047*	0.183	0.164	0.458
4/24/85	0.014	0.00080	<0.014	0.094	0.009	0.195
5/08/85	0.011	0.0013	<0.011	0.038	<0.015	0.108
5/22/85	<0.012	<0.00025	<0.030	0.072	0.015	0.102
6/05/85	0.014	0.00074	0.033	0.058	0.055	0.113
6/19/85	0.014	<0.0010	0.026	0.044	<0.006	0.084
7/24/85	0.012	<0.00020	<0.023	0.051	<0.0060	0.028
8/29/85	0.0057	<0.00025	<0.021	0.017	<0.017	0.047

(a) Values reported in mg/L.

TABLE III-7
PCP CONCENTRATIONS IN SURFACE WATER FOR SBC RI,
1984-1985

Station	Location	Dates	Concentrations (ppm)	Proposed WQ Criteria[a] (ppm)
SS-06	Just below Mt. Post and Pole above Colorado Tailings	12/03/84	0.054[b]	.048
SS-07	Downstream of Mt. Post and Pole several hundred yards. Below Colorado Tailings.	12/04/84	0.055[b]	.048
SS-06	See above.	2/25/85	0.200[b]	.048
SS-06 Dup.		2/25/85	0.240[b]	.048
SS-07	See above.	2/25/85	0.014[b]	.048
SS-06	See above.	4/22/85	0.025[b]	.048
SS-06 Dup.		4/22/85	0.027[b]	.048
SS-07	See above.	4/22/85	0.048[b]	.048
SS-05	Above Mt. Post and Pole, below Mt. Street Bridge.	7/22/85	<0.00044[b]	.048
SS-06	See above.	7/22/85	0.029	.048
SS-07	See above.	7/22/85	0.019	.048

(a) Hedtke and Arthur 1985.

(b) Analyzed past holding time.

FIGURE III-1

TOTAL ARSENIC CONCENTRATIONS IN THE DISCHARGE FROM THE WILDLIFE PONDS (PS-11A) DURING THE SBC RI.

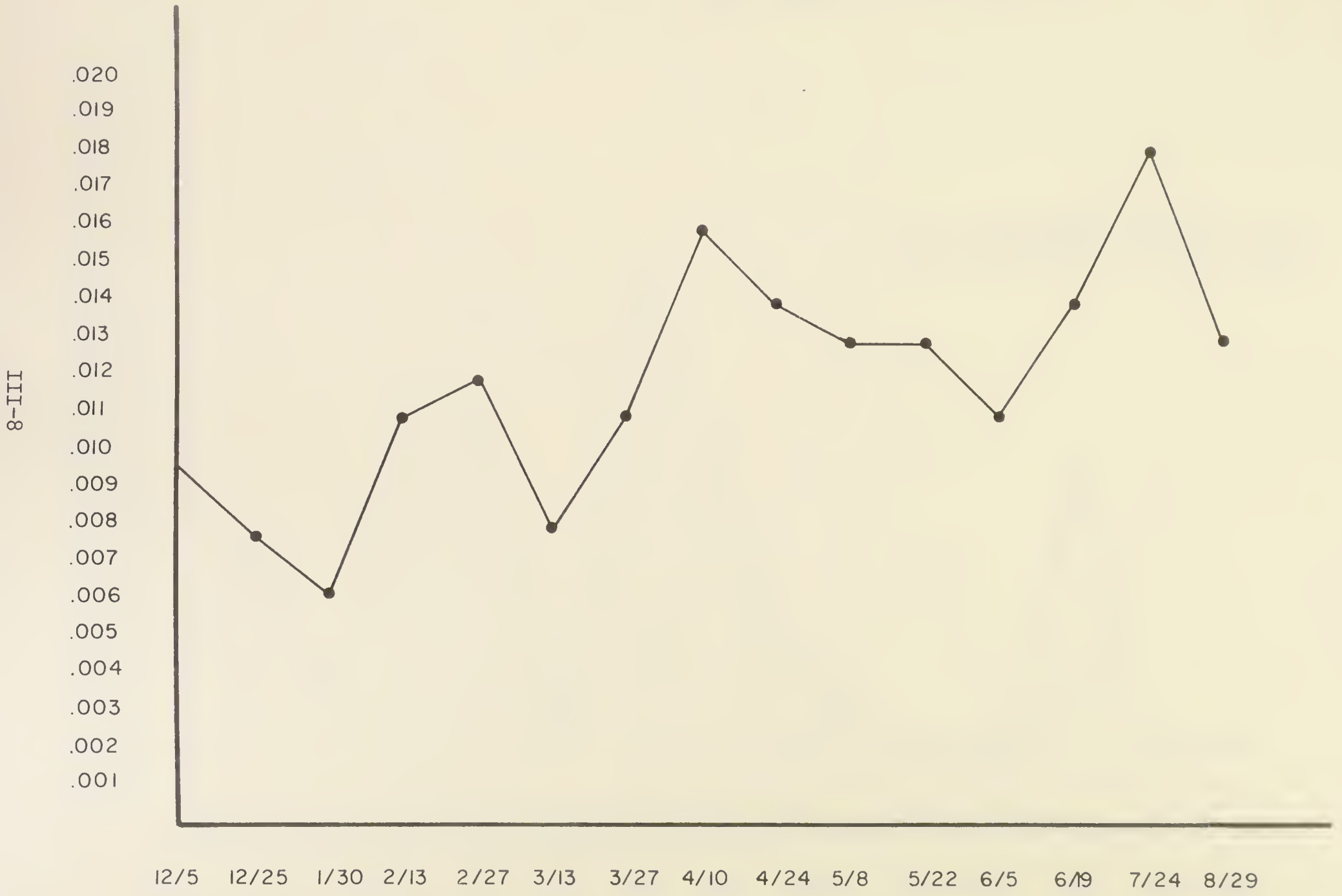


FIGURE III-2

TOTAL CADMIUM CONCENTRATIONS IN THE DISCHARGE FROM THE WILDLIFE PONDS (PS-11A) DURING THE SBC RI

All concentrations were less than the calculated MDL which is plotted

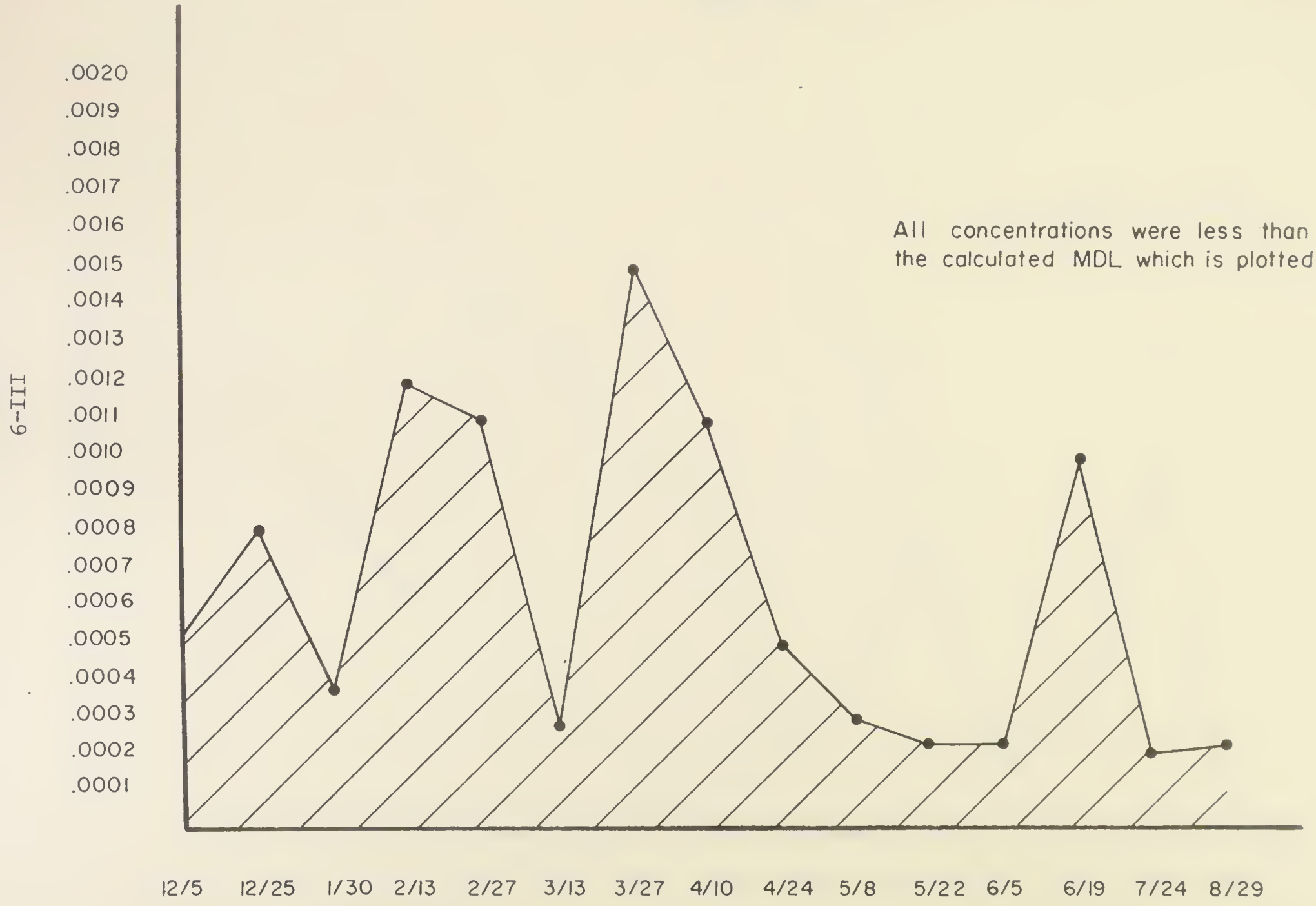


FIGURE III-3

TOTAL COPPER CONCENTRATIONS IN THE DISCHARGE FROM THE WILDLIFE PONDS (PS-11A) DURING THE SBC RI.

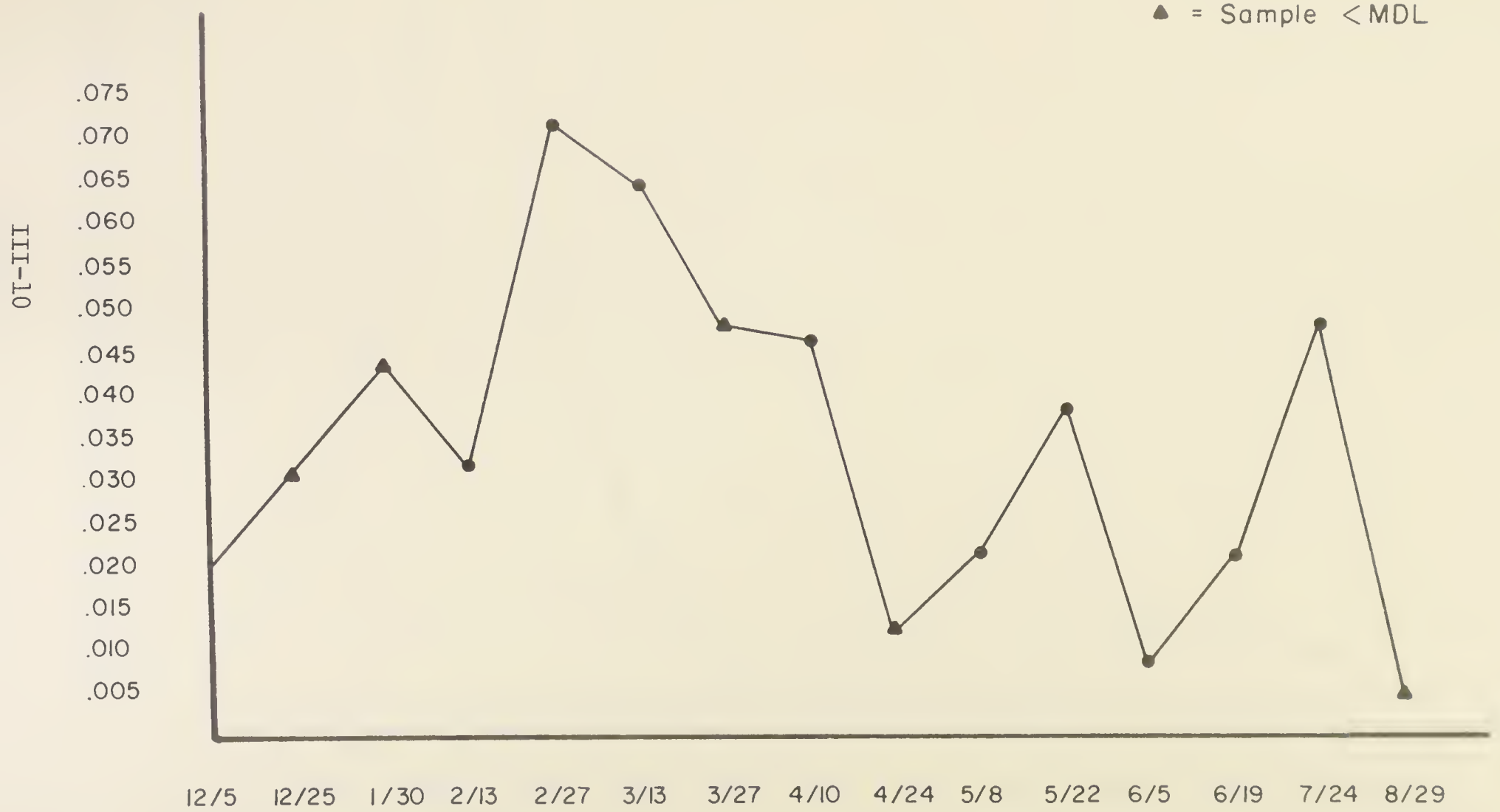
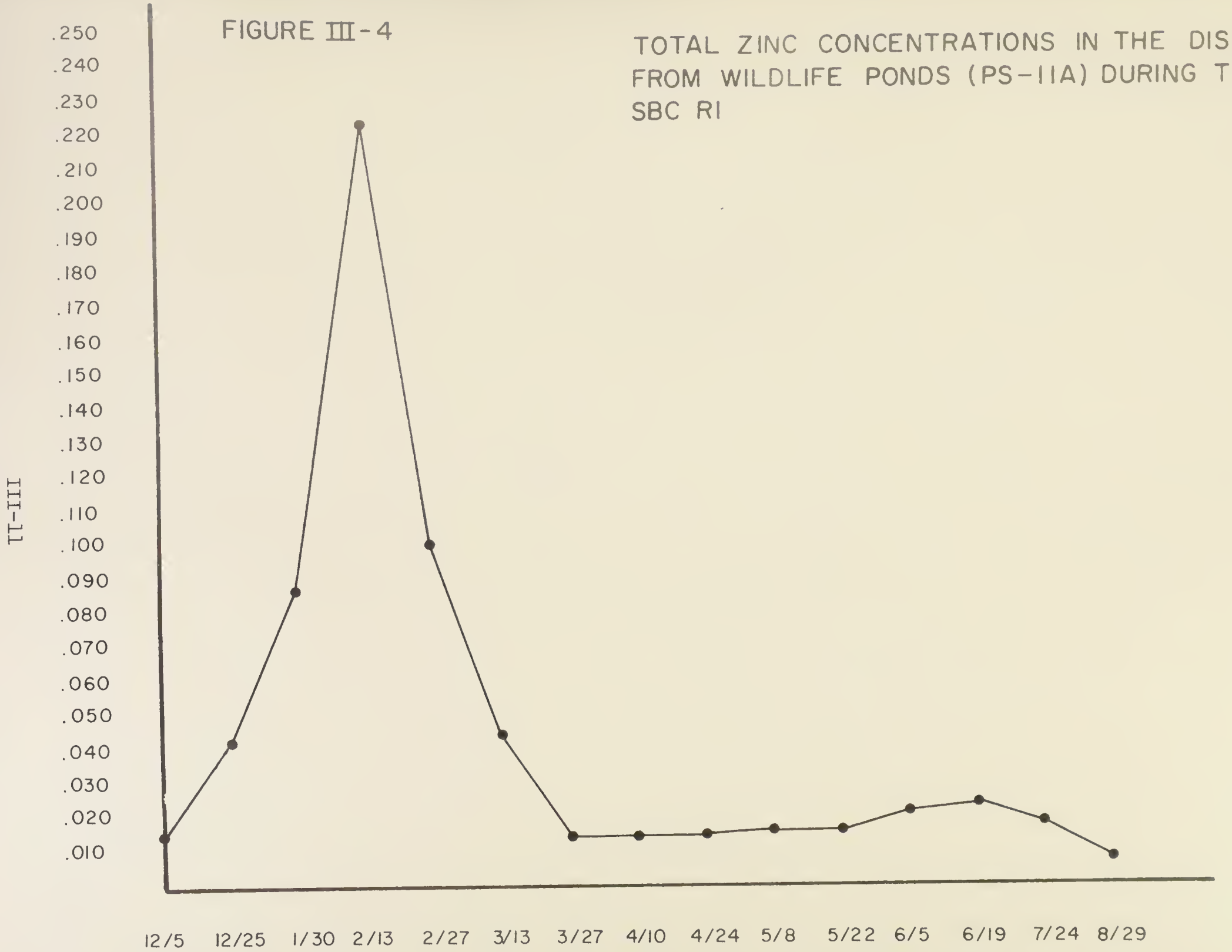


FIGURE III-4

TOTAL ZINC CONCENTRATIONS IN THE DISCHARGE FROM WILDLIFE PONDS (PS-11A) DURING THE SBC RI